

NASA

Energy
A Continuing
Bibliography
with Indexes

NASA SP-7043 (23)
October 1979

National Aeronautics and
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ACCESSION NUMBER RANGES

Accession numbers cited in this Supplement fall within the following ranges:

IAA (A-10000 Series)

A79-32247 – A79-43832

STAR (N-10000 Series)

N79-21994 – N79-28117

Previous publications announced in this series/subject category include:

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ENERGY

A Continuing Bibliography

With Indexes

Issue 23

A selection of annotated references to unclassified reports and journal articles that were introduced into the NASA scientific and technical information system and announced from July 1 through September 30, 1979 in

- *Scientific and Technical Aerospace Reports (STAR)*
- *International Aerospace Abstracts (IAA).*



Scientific and Technical Information Branch

1979

National Aeronautics and Space Administration

Washington, DC

INTRODUCTION

This issue of *Energy: A Continuing Bibliography with Indexes* (NASA SP-7043(23)) lists 1786 reports, journal articles, and other documents announced between July 1, 1979 and September 30, 1979 in *Scientific and Technical Aerospace Reports (STAR)* or in *International Aerospace Abstracts (IAA)*. The first issue of this continuing bibliography was published in May 1974 and succeeding issues are published quarterly.

The coverage includes regional, national and international energy systems; research and development on fuels and other sources of energy; energy conversion, transport, transmission, distribution and storage, with special emphasis on use of hydrogen and of solar energy. Also included are methods of locating or using new energy resources. Of special interest is energy for heating, lighting, for powering aircraft, surface vehicles, or other machinery.

Each entry in the bibliography consists of a standard bibliographic citation accompanied in most cases by an abstract. The listing of the entries is arranged in two major sections, *IAA Entries* and *STAR Entries* in that order. The citation, and abstracts when available, are reproduced exactly as they appeared originally in *IAA* or *STAR* including the original accession numbers from the respective announcement journals. This procedure, which saves time and money accounts for the slight variation in citation appearances.

Five indexes -- subject, personal author, corporate source, contract number, and report number -- are included. The indexes are of the cumulating type throughout the year, with the fourth quarterly publication containing abstracts for the fourth quarter and index references for the four quarterly publications.

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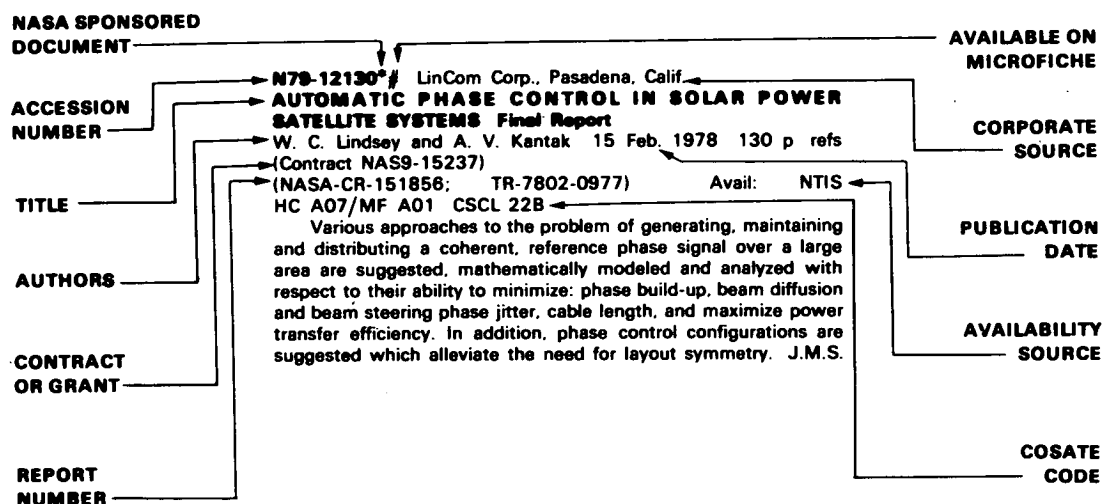
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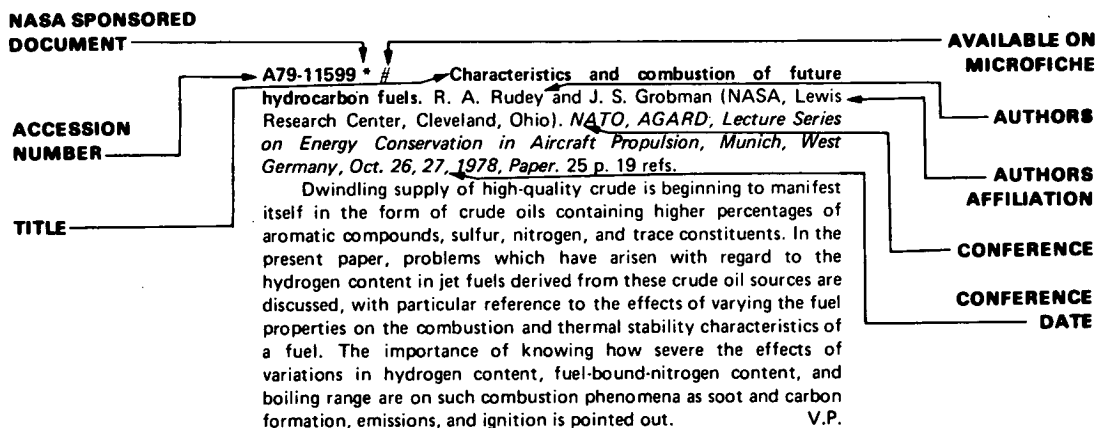
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TYPICAL CITATION AND ABSTRACT FROM IAA



A Listing of Energy Bibliographies Contained In This Publication:

1. Hydrogen energy. A bibliography with abstracts p0540 N79-22613
2. Solar thermal power generation. A bibliography with abstracts p0540 N79-22614
3. Heat pipe technology. A bibliography with abstracts p0546 N79-23364
4. Corrosion of stainless steel, volume 2. A bibliography with abstracts p0553 N79-24143
5. Wind engineering research digest, volume 3, 1978 --- a bibliography of ongoing research projects p0567 N79-24621
6. Heat pipes, volume 3. Citations from the Engineering Index data base p0569 N79-25360
7. Heat pipes volume 3. Citations from the NTIS data base p0569 N79-25361
8. Solar thermal components: A bibliography with abstracts p0570 N79-25479
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10. Forecasts of energy technology. Citations from the International Aerospace Abstracts data base p0575 N79-25531
11. Solar energy for agricultural and industrial process heat p0597 N79-27688

OCTOBER 1979

IAA ENTRIES

A79-32249 High temperature, high pressure electrostatic precipitation. J. R. Bush, P. L. Feldman, and M. Robinson (Research-Cottrell, Inc., Somerville, N.J.). *Air Pollution Control Association, Journal*, vol. 29, Apr. 1979, p. 365-371. 8 refs.

The feasibility of electrostatic precipitation at temperatures and pressures varying from ambient condition to 1366 K and 3550 kPa, respectively, has been demonstrated in a laboratory wire-pipe electrode system. Stable corona discharges are obtained at all temperatures subject to appropriate choices of electrode dimension, polarity, and pressure. Current-voltage characteristics are reported for dry air, a simulated combustion gas, and a substitute fuel gas. The effects of temperature, pressure, electrode geometry and polarity on sparkover voltage, corona-starting voltage, and current are evaluated. A precipitator performance model is included to incorporate this data into a high temperature, high pressure (MTHP) precipitator design. This model has been evaluated for an electrostatic HTHP precipitator following a pressurized fluidized bed combustor at 1089 K and 920 kPa. It is recommended that prototype HTHP electrostatic precipitators be applied to pilot coal gasifiers and fluidized bed combustors to obtain detailed design data and to verify the accuracy of the performance model under actual operating conditions.

(Author)

A79-32331 # Application of aircraft derivative and heavy duty gas turbines in the process industries. M. C. Doherty (General Electric Co., Schenectady, N.Y.) and D. R. Wright (General Electric Co., Industrial Gas Turbine Programs Dept., Stamford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-12*. 11 p. Members, \$1.50; nonmembers, \$3.00.

Typical applications of aircraft derivative and heavy duty gas turbines in petroleum production and refining, natural gas processing, ethylene, ammonia, LNG processing plants and offshore platforms are reviewed. Guidelines are included to illustrate how gas turbines can be applied to minimize fuel consumption and cooling water requirements and optimize space utilization.

(Author)

A79-32332 # Repowering of a small utility - A unique solution to a unique problem. L. F. Fougere (Fern Engineering Co., Inc., Bourne, Mass.), H. G. Stewart (Citizens Utilities Co., Stamford, Conn.), and J. Bell (John Brown Engineering, Clydebank, Scotland). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-15*. 8 p. Members, \$1.50; nonmembers, \$3.00.

Citizens Utilities Company's Kauai Electric Division is the electric utility on the Island of Kauai, fourth largest and westernmost as well as northernmost of the Hawaiian Islands. As a result of growing load requirements, additional generating capacity was required that would afford a high level of reliability and operating flexibility and good fuel economy at reasonable capital investment. To meet these requirements, a combined cycle arrangement was completed in 1978 utilizing one existing gas turbine-generator and

one new gas turbine-generator, both exhausting to a new heat recovery steam generator which supplies steam to an existing steam turbine-generator. Damper controlled ducting directs exhaust gas from either gas turbine, one at a time, through the heat recovery steam generator. The existing oil-fired steam boiler remains available to power the steam turbine-generator independently or in parallel with the heat recovery steam generator. The gas turbines can operate either in simple cycle as peaking units or in combined cycle, one at a time, as base load units. This arrangement provides excellent operating reliability and flexibility, and the most favorable economics of all generating arrangements for the service required. (Author)

A79-32341 # Application of a hot air turbine for efficiency improvement in MHD/steam power plants. S. Way. *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-36*. 7 p. 5 refs. Members, \$1.50; nonmembers, \$3.00.

It is possible to gain 2 percent to 3 percent efficiency points in the MHD/steam combined cycle by application of a hot air turbocompressor. This gain is accomplished without any increase of air preheat temperature. Moreover, the size of the steam boiler and turbines in the bottom plant is reduced in the arrangement here proposed, all the compressed and preheated air expands through the turbine, rather than having a flow division as in older design concepts.

(Author)

A79-32344 # The effect of environmental regulations on the General Electric research and development program for combustion turbines using coal-derived fuels. N. R. Dibelius, R. J. Ketterer (General Electric Co., Gas Turbine Div., Schenectady, N.Y.), and G. B. Manning (U.S. Department of Energy, Washington, D.C.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-41*. 10 p. 8 refs. Members, \$1.50; nonmembers, \$3.00.

A79-32345 # Application of the Centaur industrial gas turbine to the central receiver concept for solar electric power. P. B. Roberts (Solar Turbines International, San Diego, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-45*. 8 p. Members, \$1.50; nonmembers, \$3.00. Research supported by the Electric Power Research Institute.

A79-32348 # An application of 3-D viscous flow analysis to the design of a low-aspect-ratio turbine. H. C. Liu, T. C. Booth (AirResearch Manufacturing Company of Arizona, Phoenix, Ariz.), and W. A. Tall (USAF, Aero Propulsion Laboratory, Wright Patterson AFB, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-53*. 9 p. 8 refs. Members, \$1.50; nonmembers, \$3.00. USAF-sponsored research.

Previously reported cascade test results verified and provided a calibration of the 3-D viscous flow analysis. This paper describes the subsequent AFAPL-sponsored technology program in which the 3-D viscous flow computer program was used to optimize the low-aspect-ratio stator of a high-work turbine stage. The optimization procedure, in conjunction with the radial distribution of energy extrac-

tion, led to innovative-but-realistic blading for advanced gas generator turbines. A turbine stage was tested with this stator, in conjunction with an appropriate rotor design. The total-to-total design-point efficiency - 92 percent at 1-percent to clearance - was achieved at 31.83 Btu/lbm specific work. In addition to stage tests, separate stator tests were conducted including a measurement of total pressure loss and stator reaction torque, which provided baseline data to assess interaction effects during stage testing with stator reaction measurements 'in vivo.' (Author)

A79-32349 # Energy conversion by means of MHD shock-wave generators combined with closed-cycle gas turbines. V. Stingelin and J. P. Budliger (Battelle, Geneva, Switzerland). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-54*. 5 p. Members, \$1.50; nonmembers, \$3.00.

The principle of the operation and the basic features of shock-wave MHD generators are described. Such generators may serve as topping devices to closed-cycle gas turbines, giving the possibility of using heat source temperatures of a few hundred degrees in excess to the inlet temperatures to the gas turbines. Cycle efficiencies and specific power ratings can be increased considerably by means of such topping devices. (Author)

A79-32357 # The optimization of heat exchanger solidity for coal-fired fluidized bed combustors. G. Miller, V. Zakkay, and S. Rosen (New York University, New York, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-78*. 8 p. 6 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. EF-75-C-01-2256.

The efficient extraction of a high-temperature working fluid from a coal-fired fluidized bed combustor depends, to a great extent, on the design of the immersed heat exchanger. Of special importance is the solidity of the cooling tubes immersed in the bed. The interaction between increasing solidity and the consequent degradation of proper fluidization and circulation is being studied at the New York University fluidized bed combustion facility. It is found that under certain conditions, the solidity of heat exchanger in the bed can be significantly increased and thus one can extract increased mass flows of clean working fluid. In addition, a variation in local solidity may be another mechanism for improving performance. (Author)

A79-32360 # Design and application of a single gas turbine matched with two tandem driven centrifugal compressors. D. W. Wood (Cooper Rolls, Inc., Mount Vernon, Ohio) and R. G. Reid (Union Gas, Ltd., Chatham, Ontario, Canada). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-81*. 4 p. Members, \$1.50; nonmembers, \$3.00.

This paper deals with the design and application of a 29,000 bhp (21,625 KW) gas turbine-compressor unit to perform the duties of high pressure ratio/low volume (storage) and low pressure ratio/high volume (transmission). To achieve this wide range of requirements, a single gas turbine was matched with two tandem driven centrifugal compressors. The paper describes the considerations and the techniques used to select the gas turbine, compressor aerodynamic performance and match the gas turbine and compressors. (Author)

A79-32361 # Utilization of the cold by LNG vaporization with closed-cycle gas turbine. G. Krey (Gutehoffnungshütte Sterkade AG, Oberhausen, West Germany). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-84*. 6

p. 7 refs. Members, \$1.50; nonmembers, \$3.00. Research supported by the Bundesministerium für Forschung und Technologie and Commission of the European Community.

In the course of the world-wide efforts to save energy, the utilization of cold in connection with the regasification of liquefied natural gas gains more and more importance. The aim is the partial recovery of the energy consumed in liquefaction. There are particular advantages when using the closed-cycle gas turbine, in which the exergy of the liquefied natural gas is transformed to electrical energy with a very high efficiency. The paper deals with the optimization, design, and operational behavior of such a plant. (Author)

A79-32362 # Application of gas turbine/compressors in LNG plants. T. T. Brown and J. K. Hubbard. *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-85*. 4 p. Members, \$1.50; nonmembers, \$3.00.

The objective of this paper is to discuss key considerations associated with selection of Gas Turbine Driven LNG (Liquefied Natural Gas) Turbo Compressors. The selection of any compressor and the ultimate performance is greatly affected by the gas turbine driver chosen. The selection of gas turbine/compressor packages is even more critical when the compressor is to operate on refrigeration service such as in an LNG plant. The selection, performance and operation will be discussed for complete gas turbine compressor packages. (Author)

A79-32365 # Study of metals erosion in high temperature coal gas streams. W. Tabakoff, A. Hamed, and J. Ramachandran (Cincinnati, University, Cincinnati, Ohio). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-88*. 5 p. 8 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. E(49-18)-2465.

In order to provide the basis for alloy selection in future turbines using pulverized coal, an investigation is undertaken to obtain a basic understanding of the mechanisms of erosion at high temperatures. The test equipment has been designed to simulate the aerodynamic and thermodynamic conditions in the turbine. This facility has the capability of providing between ambient and a 1093 C (2000 F) environment temperature for erosion testing of various materials. The effects of high temperature on the erosion rate was determined and the test results from 304 stainless steel alloy are presented. (Author)

A79-32366 # Application of recuperative gas cycles with a bypass heat generator to solar energy power plants. Z. P. Tilliette and B. Pierre (Commissariat à l'Energie Atomique, Centre d'Etudes Nucléaires de Saclay, Gif-sur-Yvette, Essonne, France). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-89*. 7 p. 6 refs. Members, \$1.50; nonmembers, \$3.00.

Gas cycles are being studied for solar energy power plants on account of the attractive prospects they offer for an efficient heat source utilization. By using a particular arrangement applicable to open or closed recuperative gas cycles, consisting of a heat generator partly bypassing the low pressure side of the recuperator, further improvements can be effected in gas turbine systems. They result in favorable conditions for power and high temperature heat cogeneration, for combined gas and steam cycles, and for flexible plant operation. Specific aspects of solar energy are investigated. They mainly concern variations in operating conditions, energy storage, energy conversion efficiency and combined cycles. Applications are made to open and closed cycle power plants. As the combination of a solar receiver with a fossil-fired auxiliary heat source is considered, fossil-fired power plants with an auxiliary solar heating are examined. (Author)

A79-32367 # A simple solar gas turbine plant. A. Kovats. *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-90.* 2 p. Members, \$1.50; nonmembers, \$3.00.

A low cost gas turbine power generating plant which uses a furnace heated by solar energy reflected by collectors is proposed for use in industrial plants or remote towns. Air would be used to transfer solar or stored heat to the gas, and ample heat transfer surfaces would only require a 10 to 20 C temperature difference between the air and gas. Heat would be stored in a relatively inexpensive material such as crushed rock or iron ore, through which air is circulated, enabling the instantaneous transfer of stored heat. The application of the proposed plant to power generation for an industrial plant operating only in the daytime would only require a small storage capacity. For power stations supplying towns, storage capacity must cover the maximum load, while storage for sunless days is considered uneconomical. A.L.W.

A79-32370 # Conceptual design of an 80,000-shp fossil-fired closed-cycle helium turbine propulsion system for naval ship applications. H.-T. Shu, S. C. Kuo, T. L. O. Horton, and E. R. Fisher (United Technologies Research Center, East Hartford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-94.* 6 p. 16 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. N00014-77-C-0735.

A79-32377 # Mechanical reliability considerations in the modern high temperature industrial gas turbine. K. J. Korta (Westinghouse Canada, Ltd., Hamilton, Ontario, Canada). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-101.* 6 p. Members, \$1.50; nonmembers, \$3.00.

The mechanical design considerations of the CW352 two shaft industrial type gas turbine are discussed with emphasis on achieving a high degree of mechanical reliability based on the extensive service experience of the company's mature 1450 F inlet machines. Problem areas of the early units are discussed and how avoidance of problems has been considered in the design of the CW352. (Author)

A79-32379 # The relationship of power and heat production with closed cycle gas turbines. H. U. Fruttschi (Brown Boveri et Cie. AG, Baden, Switzerland). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-103.* 4 p. 5 refs. Members, \$1.50; nonmembers, \$3.00.

Means of deriving heat from closed-cycle gas turbines include increasing the cycle pressure ratio somewhat above its optimal value, increasing the temperature at the compressor inlet, and reducing the number of intercoolers. In closed cycle turbines designed for optimal power conversion, the outlet temperatures of the repeatedly inter-cooled compressors are too low to provide a great deal of heat production. Cycle gas inventory control may be a means of combining power and heat production in closed gas turbines. In this paper, attention is given both to fossil fuel plants and to high-temperature nuclear reactors with helium turbines. J.M.B.

A79-32380 # Development progress on the atmospheric fluidized bed coal combustor for cogeneration gas turbine system for industrial cogeneration plants. R. S. Holcomb (Oak Ridge National Laboratory, Oak Ridge, Tenn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-104.* 5 p. 7 refs. Members, \$1.50; nonmembers, \$3.00. Research supported by the U.S. Department of Energy.

A79-32381 # The role of the ceramic heat exchanger in energy and resource conservation. C. F. McDonald (General Atomic Co., San Diego, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-106.* 13 p. 55 refs. Members, \$1.50; nonmembers, \$3.00.

The approaching era of strict energy conservation and eventual energy shortage will have a profound effect on the design of process and power-producing plants, since in the future maximum fuel utilization efficiency will be of the essence. For future power conversion systems, and in particular open- and closed-cycle gas turbines, emphasis will be placed on maximizing efficiency, and in many cases this can be achieved only by significant increases in operating-temperatures. For future gas turbines, process heat plants, chemical plants, basic industries, and waste heat recovery applications, the high level of reject temperature will necessitate the utilization of ceramic heat exchangers for thermal energy recovery. In this paper, current development activities in the field of ceramic heat exchangers for gas turbine applications are discussed, and it is projected that the encouraging results from these programs will stimulate a broader interest in high-temperature waste heat energy recovery. The future role the ceramic heat exchanger will play in energy recovery for different industrial applications is emphasized, and appropriate heat exchanger design criteria, types of construction, surface geometries, and development activities are briefly discussed. (Author)

A79-32396 # Analytical consideration of fuel economy and dynamic response of a regenerative high temperature automobile gas turbine. I. T. Itoh, T. Takeuchi, T. Ishida, S. Yamazaki, and H. Kosuge (Nissan Motor Co., Ltd., Central Engineering Laboratories, Yokosuka, Japan). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-127.* 10 p. 8 refs. Members, \$1.50; nonmembers, \$3.00.

The regenerative high-temperature gas turbine engine for passenger cars is discussed from the standpoint of fuel economy. The discussion focuses on analysis of steady-state performance of high-temperature gas turbine engine and on static and dynamic model of regenerators. For analysis of the dynamic characteristics of the regenerative gas turbine engine, the use of a mathematical model is proposed for an engine simulator employing a hybrid computer. The high-temperature ceramic gas turbine satisfies the fuel-economy requirements. S.D.

A79-32400 # GUD - An unfired combined cycle approach to energy utilization. M. Mayer (Kraftwerk Union AG, Mulheim, West Germany). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-131.* 10 p. Members, \$1.50; nonmembers, \$3.00.

The position occupied by the gas turbine in the present production of electric energy is discussed in the context of possibilities for better utilization of the thermal energy used, i.e., of increasing the cycle efficiency. The influence of the fuel type, which becomes important for the economic viability of the plant as well as for comparison with different power plant systems, is considered in detail. Due to the fact that the predominant reserves of energy are to be found in the gas turbine's waste heat, the design basis for a system utilizing this available energy source is discussed. The heavy-duty KWU gas turbines are used to provide an introduction to the so-called GUD (Gas-und-Dampf) waste heat recovery system. The basic scheme is stated, and the influence which the specific site conditions have on its extension are noted. The operation of the GUD plant, particularly the start-up and emergency shutdown devices, is described. Conclusions are drawn relative to the further development of the unfired combined cycle. A.A.

A79-32406 # Fuel effects in recent combustion turbine burner tests of six coal liquids. P. W. Pillsbury (Westinghouse Electric Corp., Eddystone, Pa.), A. Cohn (Electric Power Research Institute, Palo Alto, Calif.), P. P. Singh (Westinghouse Electric Corp., Pittsburgh, Pa.), T. R. Stein (Mobil Research and Development Corp., Paulsboro, N.J.), and P. R. Mulik. *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-137.* 8 p. 7 refs. Members, \$1.50; nonmembers, \$3.00. Research supported by the Electric Power Research Institute.

Comparative tests have been made in combustion turbine burners between six coal derived liquid (CDL) fuels and No. 2 distillate oil. All CDL fuels were evaluated in a half-scale (by diameter) combustor test rig, while one CDL fuel was also evaluated in a full scale high pressure combustion rig. The effects of these fuels on emissions of smoke and oxides of nitrogen, and on combustor metal temperature are discussed. Also observed in the testing were flame radiation, post-test combustor cleanliness, and emissions of carbon monoxide and hydrocarbons. Two of the CDLs do appear to be within the tolerance band which present combustion turbines can accept, with the exception of elevated NOx emissions. This work is part of an Electric Power Research Institute program to develop burners for coal derived liquids. (Author)

A79-32407 # Operation of a GT-225 diffusion-flame combustor on alternative fuels performance, durability and emissions. D. C. Hammond, Jr. (GM Research Laboratories, Warren, Mich.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-138.* 9 p. 7 refs. Members, \$1.50; nonmembers, \$3.00.

Ten fuels were burned in a GT-225 diffusion-flame combustor to evaluate performance, durability, and emissions. The fuels were: reference kerosene, three petroleum distillates, two alcohols, one coal-derived fuel, a fuel made from tar sands, and two fuels made from oil shale. The more volatile petroleum distillates were observed to burn more efficiently than kerosene, with the alcohols and the more viscous synthetic fuels exhibiting combustion efficiencies slightly lower than that of kerosene. The synthetic fuels having high aromatic contents were shown to produce higher flame-tube-wall temperatures than kerosene, although not sufficiently high to reduce durability. Oxides of nitrogen emissions were found to be 60 to 80% lower in alcohols than in kerosene, whereas carbon monoxide emissions, 650% higher. Large amounts of nitrogen were noticed in the synthetic fuels. A.A.

A79-32416 # Major considerations in the design and engineering of cogeneration facilities. R. E. Kropp, E. J. Hansen (Dravo Cogeneration Co., Pittsburgh, Pa.), and R. Destefanis (Gibbs and Hill, Inc., New York, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-151.* 5 p. Members, \$1.50; nonmembers, \$3.00.

Since the 1973 oil embargo, cogeneration has received renewed attention, particularly from industry and government. The paper summarizes the various options, aspects, and considerations which may be considered in the study, design and engineering of industrial cogeneration facilities. Emphasis is placed on large grass roots fossil fired facilities. However, these facilities probably will not be the short-term solutions to the U.S. energy dilemma. One of the prime short-term solutions appears to be waste stream utilization with gas turbines. S.D.

A79-32420 # Conceptual design of a pulverized coal furnace for a utility size closed-cycle, gas-turbine power plant. H. J. Strumpf (AiResearch Manufacturing Company of California, Torrance, Calif.).

American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-158. 10 p. Members, \$1.50; nonmembers, \$3.00. Contract No. EF-77-C-01-2611.

A study has recently been completed on the conceptual design of coal-fired, closed-cycle, gas-turbine power plants that operate at high turbine-inlet temperatures and use air as the cycle fluid. This paper describes the design of one type of heater system for such a power plant - a pulverized coal furnace. Designs are presented for a 843 C turbine inlet temperature cycle that utilizes metallic super-alloy heat exchanger tubes and a 954 C turbine inlet temperature cycle that utilizes ceramic heat exchanger tubes. The heaters consist of two sections - a radiant section where heat is transferred primarily by radiation from the pulverized coal luminous flame, and a convective section where heat is transferred primarily by forced convection from the nonluminous combustion gas. To maintain flame stability in the furnace, a minimum power density criterion must be met. This requires modularization of the radiant heaters.

(Author)

A79-32421 # DD-963 Class waste heat recovery system experience. T. E. Graf and J. E. Nagegast (U.S. Navy, Naval Ship Engineering Center, Philadelphia, Pa.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-159.* 12 p. Members, \$1.50; nonmembers, \$3.00.

The DD-963 Class ships are the first U.S. Navy vessels to utilize a waste heat recovery system on a gas turbine engine. This paper will present the experience gained from the three years of shipboard operation with the system. The experience will be used to develop areas for consideration that can improve the probability of success in future system procurements. The areas to be considered are: (1) the need for definitive military specifications; (2) the need to test at Navy laboratories; and (3) the need to test complete systems under simulated shipboard conditions. (Author)

A79-32422 # Effects of the combustion products of coal-derived fuels on gas turbine hot-stage hardware. C. T. Sims, H. Doering, and D. P. Smith (General Electric Co., Schenectady, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-160.* 8 p. Members, \$1.50; nonmembers, \$3.00. Research sponsored by the U.S. Department of Energy.

This paper reports a DOE-sponsored program to evaluate the effect of the combustion products of coal-derived fuels on current and potential materials used in gas turbine hot-section components and on the plugging of cooling holes in air-cooled airfoils. Atmospheric-pressure small burner rigs and a combustor operating at elevated pressures and design air flows, equipped with a segment of a first-stage nozzle (turbine simulator), were used in these evaluations. (Author)

A79-32424 # Combined cycles for pipeline compressor drives using heat. W. F. Malewski and G. M. Holldorff (Borsig GmbH, Berlin, West Germany). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-162.* 16 p. Members, \$1.50; nonmembers, \$3.00.

Combined cycles for pipeline-booster stations using waste heat from gas turbines exhaust can improve the overall efficiency of such stations remarkably. Several working fluids are suitable. Due to existing criteria for selecting a working medium under mentioned conditions, water, ammonia, propane and butane can be considered as practical working fluids. The investigations have shown that: (1) ammonia is advantageous at low exhaust gas and ambient tempera-

tures, (2) water is most effective at high exhaust gas and ambient temperatures, and (3), additionally, hydrocarbons are suitable in a medium range for exhaust gas and condensing temperatures. Not only thermodynamic but also operational features have to be considered. There is not one optimum working fluid but a best one suitable according to the prevailing site conditions. (Author)

A79-32428 # Pressurized fluidized bed coal combustion exposure testing of gas turbine and heat exchanger materials. M. S. Nutkis (Exxon Research and Engineering Co., Linden, N.J.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-166.* 7 p. 5 refs. Members, \$1.50; nonmembers, \$3.00.

The Exxon Research pressurized fluidized bed (PFB) coal combustion facility, known as the miniplant, was constructed to demonstrate the feasibility of this coal combustion technique for environmentally acceptable energy production. This facility has been in operation since 1974, and has operated for 2500 test hours, during which over 600,000 lb of 2-4% sulfur coal were combusted in beds of limestone or dolomite. The paper shows that encouraging information is obtained from the miniplant hot corrosion/erosion test concerning the ability of certain heat exchanger and gas turbine materials to exist in a pressurized fluidized bed combustion environment. Although the tests were of short duration, many materials appear promising, and long-term direct hot corrosion/erosion of turbine material under actual PFB coal combustion conditions is needed for firm establishment of relevant criteria. S.D.

A79-32429 # Application of a power recovery system to gas turbine exhaust gases. N. P. Baudat and O. R. James (B & C Associates, Inc., Houston, Tex.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-167.* 9 p. 14 refs. Members \$1.50; nonmembers, \$3.00.

This paper discusses the application of a power recovery system to recover waste heat from the exhaust gases of gas turbines and convert this energy into shaft horsepower. Also discussed are power cycles, selection of power fluid, equipment selection, and application of the power recovery system to various gas turbines. Several charts and tables are included: process flow diagram, cycle efficiencies, curve for estimating recoverable horsepower. (Author)

A79-32433 # Development of an industrial gas turbine combustor burning a variety of coal-derived low Btu fuels and distillate. R. A. Battista and R. A. Farrell (General Electric Co., Gas Turbine Div., Schenectady, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-172.* 14 p. 13 refs. Members, \$1.50; nonmembers, \$3.00.

An industrial gas turbine combustor has been developed which is capable of operating over the gas turbine load range on a variety of coal-derived low Btu gases as well as No. 2 distillate fuel. At gas turbine cycle conditions using simulated coal-derived low Btu gas, CO emissions and combustor blowout characteristics are comparable to those obtained with current product line combustors burning No. 2 distillate. The results of laboratory single burner combustion tests with simulated low Btu gases, ranging in heating value from 809 to 1369 kcal/NM cubed (91-154 Btu/scf), are described. Parametric studies were also conducted in which the moisture content of the fuel (at constant volumetric lower heating value) and heating value were varied. The results of these tests are compared with those obtained with a conventional constant cross-sectional area combustor and those of other investigators. (Author)

A79-32434 # A high temperature turbine for operation on coal-derived fuel. J. M. Mogul, J. C. Wolf (Curtiss-Wright Corp., Wood-Ridge, N.J.), and W. W. Bunker (U.S. Department of Energy, Washington, D.C.). *American Society of Mechanical Engineers, Gas*

Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-173. 9 p. Members, \$1.50; nonmembers, \$3.00. Contract No. EX-76-C-01-2291.

An opportunity exists for generating clean, high efficiency electric power from coal by integrating a low Btu coal gasification system with a combined gas turbine-steam turbine cycle. Achieving this objective is dependent on developing a gas turbine which can operate at temperatures over 2600 F (1427 C) in a combusted coal-gas environment. Transpiration-air-cooling of hot section blades and vanes is a concept which can effectively deal with both high gas temperatures and the aggressive atmosphere. A description of the concept, early test experience, and the building block testing approach for evaluating transpiration-air-cooling on simulated coal derived fuel are discussed. (Author)

A79-32437 # Laser-particulate control for open-cycle, coal fired gas turbines. T. E. Botts and J. R. Powell (Brookhaven National Laboratory, Upton, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-177.* 5 p. 8 refs. Members, \$1.50; nonmembers, \$3.00.

Direct coal-fired gas turbines need efficient high temperature particulate control in order to be an attractive option for the efficient conversion of coal to electrical energy. Particulates in the range of three to ten microns are very difficult to remove and it is, therefore, proposed that they be fragmented into particulates below the threshold size for turbine blade erosion using pulsed CO₂ lasers. Beam interaction with combustion products is considered. A 1000-MW(e) conceptual plant is presented to demonstrate costs and recirculating power requirements. (Author)

A79-32449 # Design of pressurized fluid-bed combustor/particulate control system for reliable turbine operation. D. L. Keairns, D. F. Ciliberti, A. Y. Ranadive, J. R. Hamm, R. W. Wolfe, and E. F. Sverdrup (Westinghouse Research and Development Center, Pittsburgh, Pa.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-190.* 8 p. 8 refs. Members, \$1.50; nonmembers, \$3.00. Research sponsored by the Westinghouse Electric Corp.; U.S. Environmental Protection Agency Contract No. 68-02-2132.

The commercial operation of coal-fired pressurized fluid-bed combustion-gas turbine plants for central station electric power generation or for industrial cogeneration applications depends on the reliable operation of the gas turbine. Reliable operation of the turbine is related to the particulate and chemical composition of the gases that it expands. This study is limited to an evaluation of particulates as they limit turbine life by erosion. Pressurized fluid-bed combustor design and operation trade-offs exist that affect the particle concentration and size ranges presented to the gas cleaning equipment. Gas cleaning equipment choices will subsequently effect the particulates going to the turbine. The development of a particle profile model permits an assessment of the effect of these decisions on the particles that enter the turbine. Turbine tolerance models previously developed by Westinghouse are then used to estimate turbine life and the incremental energy cost penalty. The scope of the evaluation procedure is presented and selected parametric cases presented to illustrate available trade-offs for design, operation, and cost. (Author)

A79-32451 # Pressurized fluidized bed pilot electric plant - A technology status. S. Moskowitz (Curtiss-Wright Corp., Wood-Ridge, N.J.), G. Weth (U.S. Department of Energy, Washington, D.C.), and A. Leon (Dorr-Oliver, Inc., Stamford, Conn.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-193.* 12 p. Members, \$1.50; nonmembers, \$3.00.

A substantial number of tests directed at providing pressurized fluidized bed combustor (PFBC) performance and heat exchanger material characteristics are conducted in support of the pilot plant design criteria and material selections. PFBC burns high-sulfur coal to produce electricity at competitive costs under environmentally acceptable conditions. It is shown that (1) PFB combustion efficiency in excess of 99% is assured; (2) NO_x and SO₂ emissions which easily satisfy the current EPA limits are achievable; (3) the air-cooled heat exchanger configuration improves heat transfer performance with the fine bed particle size distribution; and (4) the use of iron- or cobalt-base alloys for the air-cooled heat exchanger tubes is satisfactory for utility life requirements. S.D.

A79-32453 # Assessment of hot gas clean-up systems and turbine erosion/corrosion problems in PFBC combined cycle systems. J. Stringer, S. Ehrlich, W. W. Slaughter, and A. C. Dolbec (Electric Power Research Institute, Palo Alto, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-195*. 13 p. 36 refs. Members, \$1.50; nonmembers, \$3.00.

Consideration is given to a system for the fluidized combustion of coal at elevated pressure using an acceptor in the fluidized bed to remove the sulfur. Steam is raised using heat exchangers within and above the bed and the hot combustion gases are expanded through a gas turbine. A serious limitation on this system is the ability to reduce the particulate loading in the combustion gases to a level at which a gas turbine having acceptable life can be constructed. The present paper considers various turbine degradation processes, with emphasis on erosion, and the probable limits of particulate loading in the gas stream are estimated. These estimates are discussed in relation to existing hot gas particulate removal systems. B.J.

A79-32455 # Heavy duty gas turbine design changes for use with low Btu coal gas. W. A. Boothe and J. C. McMullen (General Electric Co., Gas Turbine Div., Schenectady, N.Y.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-198*. 8 p. 6 refs. Members, \$1.50; nonmembers, \$3.00.

An MS5000 gas turbine is now being redesigned for integrated operation on low Btu Lurgi coal gas in the Powerton Gasification Combined Cycle Test Facility. Air is extracted from the machine to provide process air for the gasifiers, and a heat recovery steam generator provides steam for the gas plant. This paper describes the design modifications to the gas turbine and its control system to accommodate such operation. Since the facility will demonstrate operation in a variety of control modes using gas produced from a wide range of domestic coals, the gas turbine control system emphasizes flexibility and incorporates several functions unique to low Btu gas applications. Major modifications to the fuel and combustion systems are also required. Test results on the resulting new combustor design are reported in a companion paper (Battista and Farrell, 1979). (Author)

A79-32456 # Designing reliability into high-effectiveness industrial gas turbine regenerators. S. J. Valentino (AiResearch Manufacturing Company of California, Torrance, Calif.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-199*. 9 p. 5 refs. Members, \$1.50; nonmembers, \$3.00.

The paper addresses the measures necessary to achieve a reliable regenerator design that can withstand higher temperatures (1000-1200 F) and many start and stop cycles - conditions encountered in high-efficiency operation in pipeline applications. The discussion is limited to three major areas: (1) structural analysis of the heat exchanger core - the part of the regenerator that must withstand the higher temperatures and cyclic duty; (2) materials data

and material selection; and (3) a comprehensive test program to demonstrate the reliability of the regenerator. This program includes life-cycle tests, pressure containment in fin panels, core-to-core joint structural test, bellows pressure containment test, sliding pad test, core gas-side passage flow distribution test, and production test. Today's regenerators must have high cyclic life capability, stainless steel construction, and long fault-free service life of 120,000 hr. S.D.

A79-32458 # Alternate ways of using bottoming cycle power in pipeline gas compressor stations. R. J. Rossbach. *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-201*. 9 p. 6 refs. Members, \$1.50; nonmembers, \$3.00. Contract No. EC-77-C-03-1181.

The General Electric Company is carrying out a design study and evaluation of bottoming cycles for gas pipeline compressor prime movers. Three sites were chosen for the study of demonstration organic bottoming cycles of about 5000 hp applied to three aircraft derivative gas turbines of approximately the same size. The purpose of the study is to design and evaluate all important aspects of installing organic bottoming cycle systems on a selected group of gas turbine prime movers driving gas compressors. As a result of the study, it was found that pipeline bottoming cycles applied to gas turbine prime movers could reduce the heat rate 35 percent more than the Department of Energy target value of 20 percent. Installation designs for three sites are described. (Author)

A79-32461 # Closed cycle gas turbines, an ECAS update. I. H. C. Daudet (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.) and C. A. Kinney (U.S. Department of Energy, Washington, D.C.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-204*. 9 p. Members, \$1.50; nonmembers, \$3.00.

The paper summarizes the Phase I results of the Closed Cycle Gas Turbine Heater Program, with particular reference to the economics and technical design features of complete coal-fired power plants utilizing closed cycle gas turbines for power conversion. The results reveal that closed cycle gas turbine power plants of a highly recuperated, nonbottomed configuration are very attractive from both economic and performance standpoints. Air is an excellent closed cycle gas turbine working fluid without the disadvantages of helium working fluid. Without the use of Rankine bottoming cycle, high plant performance can still be achieved by using a metallic combustor heat exchanger system and a high level of recuperation. This results in closed cycle gas turbine power plant designs with near-term technology and low cost of electricity. Adaptability to either wet or dry cooling provides siting flexibility. S.D.

A79-32462 # A 2500 HP addition to the Ruston range. P. M. Andronowski (Ruston Gas Turbines, Ltd., Lincoln, England). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper 79-GT-205*. 8 p. Members, \$1.50; nonmembers, \$3.00.

The newly introduced Ruston TA2500 gas turbine, based on the design of the well proven TA1750, is described. Component efficiencies have been improved to increase the overall thermal performance, and the Ruston designed solid-state control system has been incorporated to give greater operating flexibility. Other changes include a compressor driven auxiliary gearbox which obviates the necessity for motor driven auxiliary pumps. A power increase of about 30% has been obtained with a reduction in specific fuel consumption of 17%. A.A.

A79-32463 # Mississippi County Community College solar photovoltaic total energy project. E. M. Henry (TEAM, Inc., Springfield, Va.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San*

Diego, Calif., Mar. 12-15, 1979, Paper 79-Sol-13. 6 p. Members, \$1.50; nonmembers, \$3.00.

The actively cooled photovoltaic demonstration system being developed to supply the total electrical and thermal energy requirements of Mississippi County Community College in Arkansas is described. Energy conservation features of the school allow it to operate at a peak demand of 4.75 W/sq foot, to be supplied by a 240 kW tracking concentrating collector system. Power conditioning will be provided by a line-commutated 300 kW solid state inverter which will supply 480 V of three phase, 60 Hz AC. An iron chloride redox battery is being developed to store ten hours of full power capacity and conventional hot water tanks will be used for thermal energy storage, with access to utility company power in case of emergencies. Process control includes the capabilities of monitoring system parameters and controlling energy supplies, storage and solar tracking. The energy system is scheduled for installation and checkout in the summer of 1979. A.L.W.

A79-32473 Small-scale magnetic fluctuations inside the Macrotron tokamak. S. J. Zweben, C. R. Menyuk, and R. J. Taylor (California, University, Los Angeles, Calif.). *Physical Review Letters*, vol. 42, May 7, 1979, p. 1270-1274. 10 refs. Research supported by the Fannie and John Hertz Foundation; Contract No. EY-76-C-03-0010.

Magnetic pickup loops inserted in the Macrotron tokamak have revealed a broad spectrum of oscillation in B sub r and B sub p up to a frequency of 100 kHz. The high frequency oscillations of B sub r have short radial and poloidal correlation lengths (L less than 5 cm), in contrast to the usual Mirnov oscillations with a frequency of 7 kHz and L much greater than 5 cm. This study represents the first observation of small-scale radial magnetic fluctuations inside a tokamak plasma. Such fluctuations can in theory cause enhanced radial energy flow through a local restructuring or destruction of the magnetic flux surfaces. B.J.

A79-32591 MHI's recent achievements in the field of geothermal power generation. K. Aikawa, S. Fukuda, and M. Tahara (Mitsubishi Heavy Industries, Ltd.; Nagasaki Shipyard and Engine Works, Nagasaki, Japan). *Mitsubishi Heavy Industries Technical Review*, vol. 15, Oct. 1978, p. 195-207.

The paper gives the technical data on about fifteen geothermal power stations throughout the world, and then goes into some more detail on some recently installed plants. Some of these are of the single flash type, where the steam-water mixture from the geothermal wells is led to a well head separator, and the separated steam is fed to a turbine for power generation. The Hatchobaru plant features a double flash cycle, in which the hot water from the separator is led to a second flasher at reduced pressure, so the water is flashed. The resulting secondary steam is fed to an intermediate stage of the turbine to increase the output. A schematic diagram of the double flash cycle plant is presented. The Hatchobaru plant also features a unique steam-water mixture transmission system. Only one transmission pipeline is required between each well and the plant. The geothermal double flash cycle power plant with two-phase flow transmission is producing 15-25% higher power generation than in the single flash cycle. Total investment cost is 5% higher than for the single flash cycle, but power generating cost is 10-20% lower. P.T.H.

A79-32592 An assessment of the gasification characteristics of some agricultural and forest industry residues using a laboratory gasifier. R. O. Williams and J. R. Goss (California, University, Davis, Calif.). *Resource Recovery and Conservation*, vol. 3, Mar. 1979, p. 317-329. 13 refs. Research supported by the California Energy Resources Conservation and Development Commission and University of California.

The conversion of various solid biomass residues to gaseous fuels is investigated. A downdraft gasifier with an eccentric rotating grate or a perforated steel basket for supporting the fuel and separating the

product gas and the ash was employed using rice hulls, cotton gin trash, wood chips, walnut shells and corn cobs as fuels. Fuel consumption, product compositions and energy balances were determined. It is found that walnut shells produce a gas of high heating value at high yield (up to 80% with two sizes of shells), however the steel basket must be used. Gas of low calorific value is produced from cotton gin trash and rice hulls, both of which have a high ash content and must be pretreated. Results indicate that corn cobs and wood chips are ideal fuels to use in a gasifier, having high calorific values and low ash contents and being of suitable size.

A.L.W.

A79-32593 Fuel gas production from animal residue. I - Technical perspective. R. L. Wentworth, E. Ashare, and D. L. Wise (Dynatech R/D Co., Cambridge, Mass.). *Resource Recovery and Conservation*, vol. 3, Mar. 1979, p. 343-358. 203 refs. Contract No. EY-76-C-02-2991.

The technology of fuel gas production by anaerobic digestion, has only recently been recognized as a potential alternate energy source. An application which shows promise to furnish energy is the digestion of animal residues. The objective of this review is to develop a detailed technical perspective of the scope of the anaerobic digestion process and the problems and prospects for exploitation to produce methane from animal residues. It is concluded that the technology of anaerobic digestion and the economics of this technology make fuel gas production from selected animal residues meritorious for development. (Author)

A79-32594 Fuel gas production from animal residue. II - An economic assessment. E. Ashare, R. L. Wentworth, and D. L. Wise (Dynatech R/D Co., Cambridge, Mass.). *Resource Recovery and Conservation*, vol. 3, Mar. 1979, p. 359-386. 20 refs. Contract No. EY-76-C-02-2991.

A mathematical model is used to determine the optimum process conditions and economics for the production of fuel gas by anaerobic digestion of animal residues. In the situation considered, a slurry of animal residues (manure) from a 10,000 head beef feedlot is fed to a digester where anaerobic microorganisms convert the organic matter to methane and carbon dioxide. The feedlot was calculated to produce 8500 cu m/day of methane at a cost of \$4.90/GJ or \$0.183/cu m, with a total capital requirement of \$1,165,000, a total capital investment of \$694,000 and an average annual net operating cost of \$370,000. An analysis of the sensitivity of the unit gas cost to feedlot size and type, digester type and operating conditions, and economic input data indicates areas in the anaerobic digestion system design where reasonable improvements may be expected in order to produce gas at a more economically feasible cost. A.L.W.

A79-32636 A new concept of thermionic converter. G. Musa (Institute of Physics and Technology of Radiation Devices, Bucharest, Rumania). *Journal of Physics D - Applied Physics*, vol. 12, Apr. 14, 1979, p. L37-L40.

The parameters of a new type of thermionic converter, which has a number of concentric electrodes, are computed. The obtained theoretical efficiency of this new type of converter is close to the efficiency of the ideal thermionic diode converter. The results obtained are explained by the reduction of the radiation loss from the emitter due to the electrode configuration. Efficiencies as high as 20% are expected from this type of converter, which is now being constructed. (Author)

A79-32697 Kinetics of desulfurization of hot fuel gas with calcium oxide - Reaction between carbonyl sulfide and calcium oxide. R. T. Yang and J. M. Chen (Brookhaven National Laboratory, Upton, N.Y.). *Environmental Science and Technology*, vol. 13, May 1979, p. 549-553. 12 refs.

The kinetics of the sorption of carbonyl sulfide by calcium oxide, a reaction in the desulfurization of fuel gases produced by coal gasification, are investigated. Rates of reactions in the temperature range 500 to 900 C were measured gravimetrically. Data for

COS concentrations of up to 0.2% in the 600 to 900 C range show a first order rate dependence. Satisfactory correlation of a grain model with shape factor 1.5 with the data indicates that the reaction front progresses linearly with time within each grain, confirming the original model. The rate at 500 C fell off rapidly with time and cannot be explained by the grain models. An activation energy of 4.3 kcal was calculated from the temperature dependence of the initial rate. It is found that the rates for COS and H₂S sorption are similar, indicating that lime is an equally effective sorbent for both pollutants. A.L.W.

A79-32721 First steps to the Solar Power Satellite. P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.), G. M. Hanley (Rockwell International Corp., Downey, Calif.), R. H. Nansen (Boeing Aerospace Co., Seattle, Wash.), and R. L. Kline (Grumman Aerospace Corp., Bethpage, N.Y.). *IEEE Spectrum*, vol. 16, May 1979, p. 52-58.

The Solar Power Satellite (SPS) concept is described in the light of the so-called reference system, developed by the Department of Energy and NASA as a guideline for evaluating the SPS's technical, environmental, economic, and societal problems. The silicon solar-array design is considered, and it is noted that in order to extend the life of the cells the reference design features CO₂ lasers mounted on the satellite to anneal the cells. The selected methods for transmitting power to earth, the questions of where and how to build the satellites and ground stations, and the projected design of the transportation system are also considered. The problems facing the SPS system are reviewed. A.A.

A79-32723 A combined irradiance-transmittance solar spectrum and its application to photovoltaic efficiency calculations. P. J. Ireland, S. Wagner, L. L. Kazmerski, and R. L. Hulstrom (Solar Energy Research Institute, Golden, Colo.). *Science*, vol. 204, May 11, 1979, p. 611-613. 9 refs.

The paper reports on the development of a new solar power density spectrum, SOLTRAN, and its application to the calculation of maximum potential efficiencies of photovoltaic cells. SOLTRAN is a combined solar irradiance-atmospheric transmittance computer model capable of predicting the direct (circumsolar radiation excluded) solar beam intensity spectrum (0.25-3.0 microns) at the earth's surface. Earlier solar spectra in the wavelength region 0.8-1.0 micron are discussed in some detail because of their importance to photovoltaic converters. It is shown that SOLTRAN correctly incorporates the accepted water absorption bands, as do Moon's (1940) spectra. The terrestrial spectra reported by Gates (1966) and Thomas and Thekaekara (1976) are found to be incorrect in this wavelength region. S.D.

A79-32875 Thermodynamic method of studying and optimizing thermochemical cycles of water decomposition at high temperature (Méthode thermodynamique de recherche et d'optimisation de cycles thermochimiques de décomposition de l'eau à haute température). C. Bernard, B. Cheynet (Grenoble, Ecole Nationale Supérieure d'Electrochimie et d'Electrometallurgie, Saint-Martin-d'Hères, Isère, France), and M. Ducarroir (CNRS, Laboratoire des Ultra-Réfractaires, Odeillo, Pyrénées-Orientales, France). *High Temperatures - High Pressures*, vol. 10, no. 4, 1978, p. 453-464. 22 refs. In French.

A79-32951 Solar-tower power plants - Optimization of the mirror field and application to the field scale effect (Les centrales électrosolaires à tour - Optimisation du champ de réflecteurs et application à l'effet de taille du champ). C. Mersier (Electricité de France, Département Essais, Chatou, Yvelines, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 1-20. 12 refs. In French.

A method for optimizing the design of the mirror fields of solar-tower installations is proposed. Two characteristics of the

mirror field are important in this method: the shape of the mirrors and their distribution. The distribution of the mirrors in the field is basically determined by orientation effects (the cosine effect), shadows, and the mirror technology. If the receiver losses are negligible, the shape of the field for a given terrain and tower depends only on the mirror surface. For nonnegligible receiver losses, the shape of the field depends strongly on the orientation of the reflected flux receiving surface. P.T.H.

A79-32952 Contribution to the study of optimal conditions for optical concentration in solar power plant designs - Reduction of the radiation spot provided by a field of heliostats by use of optimized conical mirrors (Contribution à l'étude des conditions optimales de la concentration optique dans les projets de centrales solaires - Réduction de la tache de rayonnement fournie par un champ d'héliostats, au moyen de miroirs coniques optimisés). P. Mallafaud (Paris VI, Université, Paris, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 21-33. 27 refs. In French.

The paper recalls the limit imposed on optical concentration by the second principle of thermodynamics and the Clausius relation. It is shown that the best optical instruments to attain this limit are conical or pyramidal mirrors. An application for a solar plant with heliostat field is examined. Data are given on the balance calculation of elementary flux through a conical mirror and the correct estimate of the losses coming from inner reflections. Technological information about proper materials giving a large reflective coefficient at high temperatures is provided. (Author)

A79-32953 Optimization of the heat transfer circuit of solar power plants using distributed solar thermal converters - Application to collectors of the THEK type (Optimisation du réseau de transfert thermique des centrales solaires à convertisseurs héliothermiques distribués - Application aux capteurs de type THEK). R. Pasqueti (Aix-Marseille I, Université, Marseille, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 35-47. In French.

This study is concerned with power plants based on a distributed network of collectors to convert solar energy into heat. The fluid transport network, between collectors and the central production unit is defined and then optimized. The method of calculation is applied to power plants using from 4 to 100,000 collectors of the THEK type, installed on a site with meteorological conditions similar to those of the Carpentras area. The predetermination of the collectors position is made by the study of shadow effects. The variations of the different energy losses and of the network cost, with the characteristic dimensions of the system, are then expressed. Taking into account physical and economical parameters, graphs are given which can be used for the optimization of the fluid transport network of THEK power plants. Finally, these graphs are used for different sizes of power plants in three cases of energy production: heat, electricity, and total energy production. The optimal and maximal size of these types of power plants, as well as their yields, are defined in each of the three cases. (Author)

A79-32955 Comparative efficiencies of solar energy collectors. M. Duban (Laboratoire de Technologie Optique, Marseille, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 57-66.

The geometric efficiencies of basic collector types are compared by examining the constancy of their collection of solar energy during a day or year, independent of their dimensions, amount of energy collected, concentration, and the use of the energy. Five basic types of collector are considered: the sun-tracking collector, the flat-plate collector, the fixed stepped cylindrical mirror, a collector rotating about an axis, and a fixed spherical mirror. A global comparison of these collectors is performed for all latitudes between 0 and 50 deg by 5-deg steps, for every month, and for the values 0 and 0.5 for the ratio of minimum power necessary for operation of the installation to the maximum power. P.T.H.

A79-32956 Selective materials for photothermal conversion of solar energy (Matériaux sélectifs pour la conversion photothermique de l'énergie solaire). J. Spitz, A. Aubert (Commissariat à l'Energie Atomique, Laboratoire d'Etudes des Matériaux Minces, Grenoble, France), J. M. Behaghel, S. Berthier, J. Lafait, and J. Rivory (Paris VI, Université, Paris, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 67-80. 34 refs. In French.

The interest in the selective surfaces for the photothermal conversion of solar energy is demonstrated. The various physical phenomena which lead to the spectral selectivity are briefly investigated. The different criteria which may be considered at the time of choosing a selective surface are described. Finally some of the results obtained with materials like black chrome, the carbides or nitrides of titanium, and doped indium oxide are described and discussed. (Author)

A79-32957 Theoretical and practical aspects of heat transfer in the window-absorber cavity of a flat plate collector (Aspects théorique et pratique des échanges thermiques dans la cavité vitre-absorbeur d'un capteur plan). A. Alexandre and J. Martinet (Ecole Nationale Supérieure de Mécanique et d'Aérotechnique, Poitiers, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 81-85. In French.

The purpose of this paper is to show how the method of Poljak's radiation exchanges in a cavity can be applied to flat solar collectors in order to render evident the internal radiative exchanges and to allow an easy calculation of collector's efficiency. This can be compared with the experimental efficiency. (Author)

A79-32959 Model of fluid flow in boilers with helicoidal coil (Modèle d'écoulement fluidique dans les chaudières à veine hélicoïdale). D. Poulighen and B. Authier (CNRS, Laboratoire d'Astronomie Spatiale, Marseille, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 91-95. 7 refs. In French.

An experimental study of pressure drops in helicoidal coils of rectangular cross section in turbulent regime was carried out on the prototype of the boiler for a spherical collector. The working fluid was hydrogenated terphenyl. The boiler consists of a cylinder 2.3 m in length and 10 cm in diameter, on which a 6 x 6 mm filament is wound, covered by a thin casing. Resistances heat the circulating fluid by infrared emission. Data on the pressure losses due to friction were obtained over a wide temperature range. P.T.H.

A79-32960 Study of refrigeration couples for solar cooling in tropical zone (Recherche d'un couple frigorigène adapté à la réfrigération solaire en zone tropicale). J. Fléchon and F. Machizaud (Nancy I, Université, Nancy, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 97-105. 20 refs. In French.

The possibilities for solar cooling offered by the use of flat plate collectors connected to a boiler containing the binary mixture NH₃/H₂O or NH₃/NaSCN were investigated. It was shown from the 1/T-log P diagrams that dry absorption, offered by CaCl₂, is the better solution for tropical climates. P.T.H.

A79-32961 Evaluation of fusion enthalpy of eutectic mixtures of fused salts used for thermal energy storage (Estimation de l'enthalpie de fusion de mélanges eutectiques de sels fondus utilisables pour le stockage thermique de l'énergie). J. P. Bros and M. Gaune-Escard (Aix-Marseille I, Université, Marseille, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 107-112. 20 refs. In French.

A simple calculation procedure is described for evaluating the enthalpy of fusion of eutectic mixtures of fused salts from the known enthalpy variations of the pure substances. The enthalpies of fusion have been determined for about forty eutectic binary and ternary molten salt mixtures. P.T.H.

A79-32962 Thermal energy storage by means of the latent heat of fusion of a mineral salt - Study of a direct contact dynamic exchanger with salt crystallization during flow (Stockage thermique de l'énergie par chaleur latente de fusion d'un sel minéral - Etude d'un échangeur dynamique à contact direct avec cristallisation du sel durant l'écoulement). J. Pantaloni, O. Favre, R. Bailleux, G. Finiels, and J. Marchisio (Aix-Marseille I, Université, Marseille, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 113-124. 28 refs. In French.

The use of a heat exchanger in which the storage medium (a mineral salt) comes into direct contact with the heat transfer agent for the recovery of thermal energy stored in molten salt is investigated. Preliminary experiments on heat transfer and phase separation in a mixture of a molten NaNO₂, NaNO₃, KNO₃ eutectic (melting point 142°C) with a synthetic oil at a temperature below the melting point of the salt show that a dynamic heat exchanger with direct contact leads to greater heat recovery by the oil than a static exchanger with natural or forced convection. A device for injecting molten salt into the heat transfer medium is used to determine the relations between injection velocity, the temperature difference between the salt and the oil, and salt particle formation. Calculations have shown the heat recovery process to have an efficiency of about 85 per cent. A.L.W.

A79-32963 Solar energy storage - Digital simulation of energy transfer by conduction and radiation in a two-phase medium (Stockage de l'énergie solaire - Simulation numérique du transfert d'énergie par conduction et rayonnement dans un milieu à deux phases). D. Gobin (Ecole Centrale des Arts et Manufactures, Châtenay-Malabry, Hauts-de-Seine, France), D. Levesque (Paris XI, Université, Orsay, Essonne, France), and C. Benard (CNRS, Laboratoire des Signaux et Systèmes, Gif-sur-Yvette, Essonne, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 125-137. 10 refs. In French.

The paper studies the time evolution of temperature distribution and the melting level velocity in a solar energy thermal storage system. The storage material used is a paraffin wax that melts at 52°C. The solar radiation comes in through a greenhouse effect. This simulation can be used to describe the behavior of roofs or walls that store solar energy as latent heat, in houses. (Author)

A79-32964 Application of a simplified Markov model to the study of a solar power plant storage system (Application du modèle Markovien simplifié à l'étude du comportement du stockage d'une centrale solaire). R. Lestienne (CNRS, Paris, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 139-144. 9 refs. In French.

The paper analyzes the main characteristics of the behavior of a storage tank coupled to a solar power plant with stochastic daily production. The correlation between productions at successive days is accounted for by using a two-state first-order Markov process, linked with probability densities of production that are different for bad days and fine days. The efficiency of the storage, as measured by the rate of demand coverage of the plant, is examined under various hypotheses and meteorological conditions corresponding to the southern part of France. (Author)

A79-32966 Production of hydrogen by a thermo-electrochemical cycle using solar energy (Production d'hydrogène au moyen d'un cycle thermo-électrochimique mettant en oeuvre l'énergie solaire). D. Steinmetz, R. Routie, and A. C. Vialaron (CNRS, Institut du Génie Chimique, Toulouse, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 153-158. 10 refs. In French.

A thermo-electrochemical cycle is considered for hydrogen production. Solar energy is used for decomposition of MgSO₄ to MgO, SO₂ and O₂. Electricity is supplied to realize electrochemical oxidation of sulfites to sulfates with hydrogen production. The electrical voltage is much less than for classical electrolysis. A flow-sheet is proposed. The feasibility of each step is demonstrated. (Author)

A79-32969 New techniques for fabricating silicon solar cells (Nouvelles techniques de réalisation de photopiles au silicium). P. Siffert (CNRS, Centre de Recherches Nucléaires de Strasbourg, Strasbourg, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 169-192. 198 refs. In French.

Currently available processes for manufacturing silicon solar cells are reviewed and some possible improvements are discussed. Consideration is given to techniques applicable to single-crystal sheets, polycrystalline silicon, amorphous silicon, and to the realization of potential barriers. B.J.

A79-32970 Concentrated silicon solar cells: Basic design - Application example (Cellules solaires au silicium sous concentration: Eléments de conception - Un exemple d'application). J. P. Berry, D. Estève, D. Folle, F. Théréz, and G. Vialaret (CNRS, Laboratoire d'Automatique et d'Analyse des Systèmes, Toulouse, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 193-199. 7 refs. In French.

The study treats the design rules for the conducting grid of concentrated silicon solar cells. Including both conduction losses and shadowing ratio, it leads to the most efficient grid, which is made of linear elements. As an example of application, the realization and the experimentation of a photovoltaic generator with concentration are described. A technico-economic evaluation is given. (Author)

A79-32971 Schottky and MIS tunnel diodes based on photovoltaic-quality hydrogenated amorphous silicon prepared by cathodic sputtering - Electrical characterization on the basis of capacitance measurements (Diodes Schottky et MIS tunnel sur silicium amorphe hydrogéné de qualité photovoltaïque préparé par pulvérisation cathodique - Caractérisation électrique par mesures capacitatives). P. Viktorovitch, D. Jousse (Ecole Nationale Supérieure d'Electronique et Radio-Electricité, Grenoble, France), A. Chenevas-Paule, and L. Vieux-Rochas (Commissariat à l'Energie Atomique, Laboratoire d'Electronique et de Technologie de l'Informatique, Grenoble, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 201-208. 16 refs. In French.

A79-32973 Photovoltaic conversion in Cu₂O (Conversion photovoltaïque dans Cu₂O). M. Tapiero, C. Noguet, J. P. Zielinger, C. Schwab, and D. Pierrat (Strasbourg I, Université, Strasbourg, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 231-236. 15 refs. In French.

Cu/Cu₂O and Cu₂O/Cu junctions have been investigated for low-cost photovoltaic solar energy conversion. The best conditions found for the formation of frontwall (deposition of Cu by evaporation or sputtering) and backwall (Cu partially oxidized) cells as well as the means to lower the series resistance, are described. Current-voltage characteristics give barrier heights always near 0.7 V and, depending on the mode of preparation, n-values of about 3 or 6; this implies the existence of interfacial states. The limited cell performances are attributed to inhomogeneities in the junctions and to the low value of the measured diffusion length (1 to 2 microns). (Author)

A79-32976 Photovoltaic effect in InSe - Application to solar energy conversion. A. Segura, J. P. Guesdon, J. M. Besson, and A. Chevy (Paris VI, Université, Paris, France). *Revue de Physique Appliquée*, vol. 14, Jan. 1979, p. 253-257. 18 refs. Research supported by the Centre National de la Recherche Scientifique.

The transport properties of indium monoselenide have been measured in n- and p-type material. Parameters for photoexcited carriers are given. Fabrication procedures for Schottky and p-n diodes are reported. Photovoltaic spectra are fitted with measured values of transport and optical parameters. InSe is shown to be a new material with attractive characteristics for solar energy conversion. Performance of InSe solar cells is discussed. (Author)

A79-32981 * Simmer-enhanced flashlamp-pumped dye laser. T. K. Yee, T. K. Gustafson (California, University, Berkeley, Calif.), and B. Fan (IBM Thomas J. Watson Research Center, Yorktown Heights, N.Y.). *Applied Optics*, vol. 18, Apr. 15, 1979, p. 1131, 1132. Grants No. DAHCO4-75-C-0095; No. NSG-2151.

It has been demonstrated experimentally that by enhancing the simmer current in the flash lamps before the energy discharge, the lamp inductance is reduced and the dye laser efficiency is thus remarkably improved. This technique has advantages over the prepulsing technique for conditioning flash lamps; the electronic circuit for the simmer enhancement is simple, inexpensive and reliable, and accurate timing is not required. Furthermore, the simmer enhancement consumes much less power, thus minimizing the attendant thermal effects and improving overall laser efficiency. B.J.

A79-32993 Microradiographs of laser fusion targets - 2-D modeling and analysis. R. L. Whitman, R. H. Day, R. P. Krüger, and D. M. Stupin (California, University, Los Alamos, N. Mex.). *Applied Optics*, vol. 18, Apr. 15, 1979, p. 1266-1274. 17 refs. Contract No. W-7405-eng-36.

A new contact microradiographic system for analyzing laser fusion targets with 2-D modeling and image analysis techniques is described. This system, which uses a monochromatic X-ray source and Kodak high-resolution plate emulsion, is sensitive to spherical wall thickness variations (eccentricities) as small as plus or minus 200 Å in hollow shells with a mean wall thickness of 1 micron. Measurements of wall thickness and of local and spherical wall thickness variations by radiographic techniques, using 2-D video, digital image analysis, and optical interferometry, are compared. (Author)

A79-33212 Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volumes A, B, & C (Congresso Brasileiro de Energia, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Anais. Volumes A, B, & C). Conference sponsored by the Conselho Nacional de Pesquisas, ELETROBRAS, Financiadora de Estudos e Projetos, NUCLEBRAS, and PETROBRAS. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979. Vol. A, 404 p.; vol. B, 449 p.; vol. C, 258 p. In Portuguese, English, and French. Price of three volumes, \$50.

Energy from biomass sources such as sorghum and palm oil, the design of windmills and solar energy collectors, and the liquefaction of high-ash coals are discussed. Attention is given both to low-cost devices suitable for use in rural underdeveloped areas (e.g., simple solar stills for fresh water production and small mills for the production of fuel ethanol from sugar cane) and to more complex technologies, such as nuclear power plants. Topics of the papers include fluidized bed combustion of coals, mechanical energy storage systems based on flywheels, metal hydride storage for hydrogen fuel, the design and performance of solar pond, and urban solid waste as an energy source. J.M.B.

A79-33213 # The solar still - A new design (Destilador solar - Um novo projeto). D. Bastos Netto and B. J. E. Zettl (Instituto de Pesquisas da Marinha, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 3-9. 10 refs. In Portuguese.

A high-efficiency solar still with a relatively simple design has been developed for the distillation of seawater and alcohol. The solar still has the advantage of being able to treat turbid waters with no loss of efficiency. The still design optimizes the relationship between condensation and evaporation surface areas; the thermodynamic process in the still is characterized by a temperature difference of tens of degrees Centigrade. J.M.B.

A79-33214 # Solar distillation in Brasil. P. J. Catania and P. C. Lobo (Parafba, Universidade Federal, João Pessoa, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 10-19. 16 refs.

Solar stills are found to be a more economical means of providing fresh water than flash distillation, reverse osmosis or vapor compression when daily requirements amount to less than 100 cu m. The basin-type solar still design examined in this paper involves simple construction and inexpensive materials. More efficient than the simple solar still is the multiple-effect still, which relies on both solar heat and latent heat of condensation for the evaporation process. J.M.B.

A79-33215 # Weightless solar energy collection. F. F. Hall (Stanford University, Stanford, Calif.). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 20-29.

Anchored weightless balloons are proposed as a design for tracking, concentrating solar collectors. The balloon concept may be less expensive than the very costly power towers which have been suggested for solar energy systems. Polyvinyl fluoride and UV-resistant sheathed aramid fiber ropes are principal components in the balloon construction. Probes for collecting solar energy in the form of heat and probes for direct conversion to electricity could be used in the solar power balloons. A large power plant with a number of 214-m diameter collectors could yield 7300 KW per collector at 81% engine efficiency. J.M.B.

A79-33217 # System data on flat-plate collectors and its optimization. H. P. Garg (Central Arid Zone Research Institute, Jodhpur, India). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 65-86. 45 refs.

Design parameters are discussed for solar energy flat-plate collectors employed for such applications as water heating, space heating, air conditioning and crop drying. Among the parameters studied for optimization are the air gap between the collector and the first glazing, coating types, and collector tilt. In addition, the effect of dirt on the transmittance of the collector plate, the interconnection of absorbers, and collector-booster systems are considered. J.M.B.

A79-33218 # Characteristics of GRP for applications in solar energy collectors (Características do GRP para aplicações em coletores de energia solar). E. Haga Júnior (São Carlos, Universidade Federal, São Carlos, São Paulo, Brazil) and A. R. O. Pinto (Campinas Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 87-99. 6 refs. In Portuguese.

Glass fiber reinforced polyester resins may provide an attractive alternative to glass or plastic for solar energy collector. In this paper, the transmittance of glass fiber reinforced polyester resins is studied as a function of laboratory aging times. On the basis of the study, differences in thermal efficiency are assessed for collectors constructed with glass fiber reinforced polyester resin or glass. J.M.B.

A79-33220 # Design construction and short term performance of a solar pond. J. N. Gorasia, (Government Engineering College, Jubbulpore, India), J. S. Saini, and C. P. Gupta (Roorkee University, Roorkee, India). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 110-118. 5 refs.

A79-33223 # Performance of a solar space heating system. S. K. Kaila, R. Ganguly, and J. S. Puri (Central Building Research Institute, Roorkee, India). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 150-159. 10 refs.

This paper discusses the performance of a solar space heating system which employs flat-plate collectors and uses water as the heat storage and circulating media. The radiative and convective heat losses from the radiating panels heat the room air. The radiative heat losses constituted more than 70 percent of the total. The total heat loss from the panel was of the order of 1.32 kW/hr. The system was found to be working satisfactorily during the 1977-78 winter.

(Author)

A79-33224 # Liquefaction of high ash Brazilian coals. J. S. V. Diaz, R. B. Peel, and C. A. Luengo (Campinas, Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 199-205. 18 refs. Research supported by the Financiadora de Estudos e Projetos.

High-pressure hydrogenation experiments have been carried out on high-ash Brazilian coals as a first step in the development of commercial power plants based on coal liquefaction. The high-ash coals consistently showed greater reactivity than did low-ash samples used as a frame of reference. This high reactivity may be due to a catalytic effect induced by the high mineral matter content of the Brazilian coals. The high-ash coals may also be suitable as feedstock for liquefaction by a hydropyrolysis process. J.M.B.

A79-33225 # Fluidized bed combustion of high ash Brazilian coals. R. B. Peel and C. A. Luengo (Campinas, Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 206-215. 10 refs. Research supported by the Financiadora de Estudos e Projetos.

A 20-cm diameter fluidized bed combustion test rig has been operated with a variety of fuels indigenous to Brazil, including high-ash coal and vegetable wastes. Wood charcoal has proved a satisfactory fuel for the ignition and operation of the combustion test rig. Problems in controlling the feed rate of the coal are discussed. J.M.B.

A79-33226 # Fluidized bed combustion of Brazilian coals (Combustão em leito fluidizado do Carvão mineral Brasileiro). C. W. A. Thober and J. C. C. C. Cunha (Fundação de Ciência e Tecnologia, Porto Alegre, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 226-235. 11 refs. In Portuguese. Research sponsored by the Companhia Auxiliar das Empresas Elétricas Brasileiras.

A demonstration model atmospheric fluidized bed combustion unit is under development for operation with high-ash Brazilian coals. The demonstration unit is intended to process about two to 10 tons per hour, and may be linked with a carbon burn-up bed to maximize thermal efficiency. The economic feasibility of fluidized bed combustion of Brazilian coal also receives attention. J.M.B.

A79-33227 # The development of alternate combustibles for diesel engines (Desenvolvimento de combustíveis alternativos para motores diesel). L. M. Ventura (Mercedes-Benz, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 236-247. In Portuguese.

Ethanol, vegetable oils and blends of diesel oil and other combustibles have been considered for use in diesel engines. High-efficiency performance was found for diesel engines fueled by a mixture of diesel oil and vegetable oil. Blends of diesel oil and gasoline also proved promising for use in the diesel engine. J.M.B.

A79-33228 # The gasification of ethyl alcohol (Gaseificação do álcool etílico). L. A. Gomes Rodrigues (Comgás, Brazil) and A. M. Sinclair. In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 248-259. 9 refs. In Portuguese.

The gasification of ethanol may yield products of industrial importance such as substitute natural gas, town gas and hydrogen. Limits on the operating temperature of ethanol gasification catalysts are discussed, and the construction of ethanol catalyzing beds is considered. Conversion of a naphtha gasification plant to ethanol is also described. J.M.B.

A79-33229 # Small mills for producing alcohol from sugar cane (Mini-usinas para álcool de cana-de-açúcar). J. M. C. S. Dias (Instituto de Pesquisas Tecnológicas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 260-268. 9 refs. In Portuguese.

A prototype mill capable of producing ethanol from sugar cane has been developed. The mill extracts 45 liters of ethanol per ton of cane processed. Problems related to contaminant microorganisms in the fermentation tanks are discussed. Mills capable of treating 500 liters of cane extract per hour are planned. J.M.B.

A79-33230 # Observations on the production of methanol and anhydrous ammonia from wood (Perspectivas para produção de metanol e amônia anidra a partir de madeira). R. M. Viegas Assumpção (Instituto de Pesquisas Tecnológicas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 269-277. 5 refs. In Portuguese.

The economic feasibility of producing methanol and anhydrous ammonia from eucalyptus timber is discussed. Installations capable of processing 1000 tons of eucalyptus per day for methanol appear to be economically viable. Production of anhydrous ammonia from eucalyptus is a less promising avenue for development. J.M.B.

A79-33231 # Hydrogen-electric power drives. F. F. Hall (Stanford University, Stanford, Calif.). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 278-287.

The paper describes briefly the following components of hydrogen-electric power drives: chilled hydrogen gas tank, liquid oxygen tank, fuel cell bank, dc/ac converter, ac drive motors, solid-state ac speed control, dc sputter-ion vacuum pumps, steam turbine generator, and steam condenser. Uses for the process steam and warm condensate are discussed, and effects on public utilities and users are weighed. P.T.H.

A79-33232 # A development program for hydrogen burners (Projeto de desenvolvimento de queimadores para hidrogenio). J. de Moraes, A. Tostes, C. A. Rodrigues, P. U. Heynemann, and M. R.

Moreira (Rio de Janeiro, Companhia Estadual de Gas, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 288-300. In Portuguese.

The addition of hydrogen to town gas (CH₄, CO and H₂), as well as to natural gas and to gases derived from petroleum liquefaction, may be a means of extending fuel reserves. The suitability of burners for use with various fuel gas mixtures is discussed, and the predictive techniques developed by Gilbert and Prigg (1957) for the combustion characteristics of gases are adopted for studying the combustion of the mixtures. Injector diameter corrections and changes in operating pressure may make industrial burners suitable for use with fuel gases containing hydrogen, or with pure hydrogen. J.M.B.

A79-33233 # Energy recovery from urban solid waste. G. M. Savage (Cal Recovery Systems, Inc., Richmond, Calif.). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 301-312. 6 refs.

This paper presents the processing techniques that are necessary for the successful recovery and utilization of a low sulfur fuel of medium heating value, namely refuse-derived fuel. Also discussed is a method of upgrading the properties of refuse-derived fuel such that the heating value, moisture content, and ash content are 19,000 KJ/Kg, 17%, and 11%, respectively. (Author)

A79-33234 # Simple methane digestors (Digestores populares de metano). B. J. E. Zetti, D. Bastos Netto, A. M. Ramos, and A. C. Muniz (Instituto de Pesquisas da Marinha, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 313-320. In Portuguese.

Simple methane digestors have been developed for the conversion of biomass to methane. The development program has focused on reducing the safety hazards and high cost of conventional fixed-wall digestors. Submerged or partially submerged plastic sacks provide the basic design innovation for the simple digestors. Tests of digestion efficiency during operations with *Eichhornia crassipes* are reported. J.M.B.

A79-33235 # Development of a unipolar electrolysis unit (Desenvolvimento de um eletrolisador unipolar). J. C. Moura and S. G. d'Ávila (Campinas Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume A.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 321-331. In Portuguese.

A low-cost unipolar electrolysis unit is under development for hydrogen fuel production on a small scale. The electrolysis unit contains several pairs of electrodes and operates at high currents. A prototype of the unipolar electrolysis unit shows that the device could function for several months without significant maintenance. A number of the electrolysis units connected in series could provide an inexpensive fuel source for small-scale industries. J.M.B.

A79-33237 # A vertical-axis bicycle rotor turbine. I - Rotor design. II - Aerodynamic aspects. M. H. Hirata and W. M. Mansour (Rio de Janeiro, Universidade Federal, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 375-400. Research supported by ELETROBRAS.

A vertical-axis bicycle-rotor wind turbine has been developed. An octagonal deflector which channels wind to the rotor is coated black to absorb solar energy and increase the speed of air passing through its channels. A stress analysis is conducted to ensure the

mechanical integrity of the rotor and to understand the mechanism which permits the horizontal spokes to support vertical lifts. Staggering of the turbine spokes for optimal aerodynamic performance is also discussed. J.M.B.

A79-33238 # A practical technique for basic windmill design (Um método prático de anteprojeto de catavento). K. L. Feng (Instituto Tecnológico de Aeronáutica, São José dos Campos, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 401-407. In Portuguese.

A parameter for the optimization of windmill performance is presented. The optimization procedure takes into account the absorption of available wind energy, the efficiency of transmission, and the size of the blades. The optimization parameter is applicable to windmills with more than one blade. J.M.B.

A79-33239 # A method for calculating the induced velocity for windmills with application to the optimization of the aerodynamic design (Um método de cálculo de velocidade induzida em cataventos com aplicação a otimização do projeto aerodinâmico). S. L. Nogueira (Centro Técnico Aeroespacial, Instituto de Pesquisas e Desenvolvimento, São José dos Campos, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 408-411. In Portuguese.

A79-33240 # The IAE 30-kW wind turbine - A review of the aerodynamic design (Turbina eólica 30 kW do IAE - Resumo do projeto aerodinâmico). O. A. Camargo do Amarante, B. M. Koike, and L. J. Faria (Centro Técnico Aeroespacial, Instituto de Atividades Espaciais, São José dos Campos, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 412-422. 12 refs. In Portuguese.

A79-33241 # Wind tunnel tests on a wind operated suction-pump-turbine system to generate electricity. J. S. de Krasinski (Calgary, University, Calgary, Alberta, Canada). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 423-434. 6 refs. Research sponsored by the National Research Council of Canada.

A study was made with the object of obtaining a high suction pumping device based on the principle of a double venturi and operated by the wind. The system would be mounted over a large diameter pipeline acting as a partial vacuum reservoir. The rotary parts consist of a low pressure turbine and generator operating between the pitot pressure of the wind and the partial vacuum of the pipeline, and are guarded from the destructive effects of the wind.

(Author)

A79-33242 # The Savonius rotor - Theory and optimization (Rotor de Savonius - Teoria e otimização). K. A. R. Ismail, I. de Carvalho Macedo (Campinas, Universidade Estadual, Campinas, São Paulo, Brazil), H. P. Cardoso, and A. C. de Barros Neiva. In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 435-447. In Portuguese.

The present work includes a theoretical model for the performance of the Savonius rotor. Calculations show the effect of both the eccentricity and the geometry on the torque and power generated. Visualization tests performed show the effect of variation of the eccentricity on the stream lines, separation, reverse flow, pressure and velocity distributions. These results were used to design a 250-watt machine which is currently under field test. (Author)

A79-33243 # A hybrid cyclogiro-Darrieus-rotor wind turbine. J. A. C. Kentfield (Calgary, University, Calgary, Alberta, Canada). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 448-463. 8 refs.

A vertical-axis wind turbine combining features of cyclogiro and Darrieus rotor designs has been developed. The wind turbine has less mechanical complexity than a conventional cyclogiro and shows better performance at low velocity ratios than a Darrieus rotor. Model tests of two- and three-bladed prototypes of the wind turbine prove that both designs are self-starting. Cyclically variable blade angles of the turbine are controlled by a simple technique involving centrifugally and aerodynamically generated forces acting on each rotor blade. The wind turbine is well suited to use with a constant-speed alternator load. J.M.B.

A79-33244 # Free-wheeling hydraulic power mills. F. F. Hall (Stanford University, Stanford, Calif.). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 464-473.

Components of free-wheeling power plants that use the hydraulic forces of winds or water currents are described. Fore and aft cones to increase throughput, multiple impellers driving a single rotor, swivel mounts to support nacelles, dc electrolytic cells for the production of H₂ and O₂, and cryogenic storage systems for the gases are the principle elements in the power mill designs proposed here. Light weight, low cost, and energy capture over the full range of hydraulic flow velocity are necessary if the free-wheeling power mills are to be feasible on the commercial scale. J.M.B.

A79-33245 # Storage of mechanical energy with flywheels - A new design concept for electric trolleybuses (Armazenamento mecânico de energia em ultravolantes - Uma nova concepção de onibus elétricos). H. I. Weber and J. Szajner (Campinas, Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 474-487. 6 refs. In Portuguese. Research supported by the Banco do Brasil.

A79-33246 # Design of a mechanical energy storage unit (Projeto de uma unidade de armazenamento mecânico de energia). F. P. L. Neto and C. de Albuquerque Rosa (Campinas, Universidade Federal, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 488-500. 5 refs. In Portuguese.

The purpose of this paper is to present the design of a mechanical energy storage unit. The stored energy capacity is analyzed in function of the material and the profile of the flywheel. The construction of flywheel consisting of steel disks spinning in a vacuum chamber is presented. (Author)

A79-33247 # The minimization of drag torque for rotating disks (Minimização do torque de arraste num volante). J. L. Scieszko and L. E. Gonçalves Bastos (Rio de Janeiro, Universidade Federal, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 501-508. In Portuguese.

An experimental program was undertaken to develop an inertial energy storage system composed of a rotating steel disk positioned between two parallel plates. Various plate-disk spacings and a number of rotations were tested as a means of minimizing the viscous drag. Drag torque data obtained for the disk varied considerably from values calculated with the model of Nece and Daily (1960), probably because the model assumes an incompressible fluid and a constant temperature and pressure. J.M.B.

A79-33249 # Latent heat storage (Armazenador de calor latente). S. A. Nebra and K. A. R. Ismail (Campinas, Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 518-529. 8 refs. In Portuguese.

A system of latent heat of fusion storage has been designed with paraffin as the working substance. A prototype apparatus has provided data on local temperatures and fluid flow in the system. The heat charging and discharging phases of operation involve different heat transfer problems which require separate analyses.

J.M.B.

A79-33251 # Hydrogen storage in the form of metal hydrides (Armazenamento de hidrogênio na forma de hidretos metálicos). M. G. Zwanziger, C. C. Santana, and S. C. Santos (Campinas, Universidade Estadual, Campinas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 542-548. 6 refs. In Portuguese.

Reversible reactions between hydrogen and such materials as iron/titanium and magnesium/nickel alloys may provide a means for storing hydrogen fuel. In this paper, a demonstration model of an iron/titanium hydride storage bed is described. Hydrogen from the hydride storage bed powers a converted gasoline electric generator.

(Author)

A79-33254 # Dimensioning of energy-production systems - The use of geometric programming (Dimensionnement de systèmes de production d'énergie - Utilisation de la programmation géométrique). A. K. Achaibou, M. De Coligny (CNRS, Laboratoire d'Automatique et d'Analyse des Systèmes, Toulouse, France), and F. Mora-Camino (Rio de Janeiro, Universidade Federal, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume B.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 656-665. 14 refs. In French.

The theory of duality in geometric programming is used to optimize an energy-production system based on a photovoltaic array. The geometric programming analysis provides a method for optimizing the solar energy system from both the economic and the energetic point of view.

J.M.B.

A79-33255 # Principal sources of electric power generation in Brazil (Principais fontes para geração de energia elétrica no Brasil). A. Coló, A. C. Tatit Holtz, and J. C. R. de Albuquerque (ELETROBRAS, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 817-830. 8 refs. In Portuguese.

A79-33256 # New energy sources - An option for the energy crisis (Novas fontes de energia - Uma opção para crise energética). M. A. Vasconcelos Nunes (ELETROBRAS, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 846-858. In Portuguese.

The author discusses several aspects of the earth's energy budget. It is pointed out that at each instant the sources of solar energy, geothermal energy, and gravitational energy are pouring out 174,000, 32, and 10 TW, respectively. The direct solar radiation available for energy conversion at the earth's surface ranges from zero to 1390 W/sq m. The diffusion and discontinuity of solar irradiation are problems in harnessing solar energy. Thermosolar and photovoltaic conversion are currently the most developed forms of solar conversion. The solar power satellite concept is being studied, and solar energy can be used in the production of hydrogen. Wind

energy and wave energy are indirect solar energy sources. A program for Brazilian efforts in new energy source exploration is outlined.

P.T.H.

A79-33257 # Training energy specialists - A proposal (Formação de especialistas em energia Uma proposta). A. Ibanez Ruiz and J. C. Balthazar (Brasília, Universidade, Brasília, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 859-869. 10 refs. In Portuguese.

A plan for educating qualified personnel to enable them to analyze all aspects of the energy problem is outlined. Three areas of study are proposed, in which three types of specialists will be trained who, acting together, will be able to cover the greater part of the spectrum of knowledge of energy production and utilization. These areas are (1) energy administration, subdivided into socio-economic analysis of energy systems, system design, energy strategies, environmental protection; (2) energy conversion, comprised of applied thermodynamics, heat transfer, fuel technology, process control, heat recuperation, energy conservation, and (3) applied mechanics, with rotor dynamics, structural analysis, applied acoustics, and stress analysis.

P.T.H.

A79-33258 # Subsidies for a formulation of a plan of action for alternative energy sources and forms (Subsídios para formulação de plano de ação para fontes e formas alternativas de energia). E. Rappel. In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 879-886. In Portuguese.

Political and financial aspects of a plan of action on the front of alternative energy sources research and development are discussed. The economic effects of energy diversification are briefly examined. Mechanisms (stimulations) and financial instruments for effecting change in energy policy are mentioned.

P.T.H.

A79-33259 # World energy scene and Brazil's alternatives (Panorama energético mundial e as alternativas Brasileiras). C. R. dos Santos Moura (ELETROBRAS, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 887-899. 5 refs. In Portuguese.

The paper summarizes the world energy situation and then focuses on the particular situation of Brazil, with emphasis on nonconventional energy sources. Brazil's use of primary energy is growing at about 7 percent per year, and current dependence on imported energy is about 40 percent. Short-term solutions to this problem might include stimulation of exploration for oil, coal, and uranium, implementation of industrial energy saving measures, and stimulation of urban transport systems. Medium-term solutions might entail development of vegetation fuel technology, coal fluidization, tidal energy systems, and development of moderate-scale solar energy systems. Long-term plans should call for nuclear fusion, hydrogen, and large-scale solar plants.

P.T.H.

A79-33260 # New policy for electrical energy (Uma nova política para energia elétrica). M. do Carmo Tombesi Guedes and R. H. de Cillo (CESP, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 910-918. 9 refs. In Portuguese.

Following a brief analysis of the Brazilian economy and the energy sector, the problem of the establishment of a rate table for electricity at the national level is discussed. With an end to imported energy in view, a revision of the Brazilian energy structure is urged.

P.T.H.

A79-33261 # Energy projects at the São Paulo State Institute of Technological Research (Projetos de energia do Instituto de Pesquisas Tecnológicas do Estado de São Paulo). I. Gochnarg (Instituto de Pesquisas Tecnológicas, São Paulo, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 928-940. In Portuguese.

The energy program aims at the development of technology for production and utilization of energy that best suits the needs and characteristics of Brazil. Three groups of studies are discussed: energy conservation, energy production, and petroleum substitutes. Very brief characterizations of planned studies on alcohol production, babassu processing, planted forests as primal energy source, anaerobic fermentation of waste material for methane gas production, and solar energy systems for multifamily use are given. P.T.H.

A79-33262 # The Coal Information Center of the Foundation for Science and Technology (O Centro de Informações Sobre Carvão Fundação de Ciência e Tecnologia). T. F. Mendes and S. L. Nunes Teixeira (Fundação de Ciência e Tecnologia, Porto Alegre, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 941-947. In Portuguese.

The paper outlines the scope of the activities of the Coal Information Center of the Foundation for Science and Technology of Brazil. The main goal of the Center is to gather, process, and disseminate information on coal to all organizations with activities in that sector. Some of the principles of journal selection and indexing are briefly mentioned. P.T.H.

A79-33263 # Sweet sorghum - A renewable source for alcohol production (Sorgo Sacarino - Um recurso renovável para produção em álcool). R. E. Schaffert, F. Giacomini, and R. A. Borgonovi (Centro Nacional de Pesquisa de Milho e Sorgo, Sete Lagoas, Minas Gerais, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 957-967. In Portuguese.

Ten sweet sorghum cultures were grown in different locations in Brazil during 1977-1978 in a study of cultivation techniques. Maturation curves are presented which indicate the evolution of the total sugar content during the cultivation cycle, enabling the determination of the optimum time for harvesting the stalks. High values of total sugar correspond to low values of extract percentage, which is of great importance in selecting the optimum harvest time. The stalk and seed producing potential of the different varieties was evaluated. P.T.H.

A79-33264 # Study of the electrochemical activity of a porous vitreous carbon (Investigação da atividade eletroquímica de um carbono poroso vítreo). A. Espinola and R. L. Correa dos Santos (Rio de Janeiro, Universidade Federal, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 968-979. 28 refs. In Portuguese.

The electrochemical behavior of a new material, a porous vitreous carbon (brand name RVC), was studied, having in view its possible utilization as an electrode material in energy cells. The useful range of potentials of the RVC was established. The observed anomalies of its electrochemical behavior may be related to changes in its surface conditions. (Author)

A79-33265 # Mechanical and vibrational problems of a vertical axis wind turbine. W. B. H. Cooke, M. E. Weekes (Saskatchewan Power Research Centre, Regina, Canada), and P. J. Catania (Parafba, Universidade Federal, João Pessoa, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 994-1002.

This paper reports on the mechanical and vibrational difficulties encountered with the operation of a prototype 4.57-m vertical axis wind turbine during the period of 1976-1977 at Regina, Saskatchewan, Canada. The work on evaluating this unit has highlighted some of the difficulties, and the second generation units should prove to be more satisfactory. (Author)

A79-33266 # Thermal radiation - Transient heat transfer in plates with selective surfaces (Radiação térmica - Transferência de calor transiente em chapas superficialmente seletivas). H. Suzuki and C. M. Hackenberg (Rio de Janeiro, Universidade Federal, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 1013-1025. 13 refs. In Portuguese. Research supported by the Financiadora de Estudos e Projetos.

A thermal diffusion model is developed to study the simultaneous radiative and conductive heat transfer on spectrally selective plates exposed to electromagnetic radiation. Experimental results were obtained, showing that the maximum error in the prediction of plate surface temperature during solar irradiation is 7 percent, which diminishes to 2 percent close to equilibrium. P.T.H.

A79-33267 # Development of Brazilian hydroelectric potential - Future prospects and planning options (Desenvolvimento do potencial hidroelétrico Brasileiro - Perspectivas e opções do planejamento). W. Jordão Filho (Companhia Internacional de Engenharia, Rio de Janeiro, Brazil). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 1026-1038. 15 refs. In Portuguese.

This paper points out the excellent remaining hydropotential of Brazil. It focuses all the alternatives available for the planners to establish an overall strategy, which provides the most adequate expanding capacity program. Special emphasis is placed on certain sources of energy, as pumped-storage, low-head and small hydro plants, and 'off-stream' storage. It is strongly recommended that hydro development stays on the peak of national energy policy at least for the next 20 years. (Author)

A79-33268 # Some economic considerations in the rush toward alternate energy sources. W. L. Hughes (Oklahoma State University, Stillwater, Okla.). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 1039-1044.

This paper compares the capital and running cost of generation of electricity using some unconventional energy sources. A nomograph is developed for this purpose. Its use as well as positive recommendations for the future selection of energy sources are given. (Author)

A79-33269 # Control of a heliostat field by distributed microcomputer technique (Commande d'un champ d'héliostats par micro-informatique répartie). A. Achaïbou and C. Bourdeau (CNRS, Laboratoire d'Automatique et d'Analyse des Systèmes, Toulouse, France). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C.

Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 1045-1058. In French.

Design principles and constraints for an automatic control system for a field of 1500 heliostats are presented. The control system is decentralized through the use of two-level microcomputers. Each heliostat is steered by a dedicated microcomputer. The field is divided into zones of twenty heliostats controlled by a microcomputer. Two servo principles are proposed, one in open loop with reference, and the other in closed loop on the center of the boiler. P.T.H.

A79-33270 # Design of an indirect-drive heliostat (Conception d'un héliostat à entraînement indirect). R. Joatton (Société Nationale Industrielle Aérospatiale, Paris France), J.-P. Gaechter (SOTEREM, S.A., Castanet-Tolosan, Haute-Garonne, France), A. Achaïbou, and C. Bourdeau (CNRS, Laboratoire d'Automatique et d'Analyse des Systèmes, Toulouse, France). In: Brazilian Conference on Energy, 1st, Rio de Janeiro, Brazil, December 12-14, 1978, Proceedings. Volume C. Rio de Janeiro, Universidade Federal do Rio de Janeiro, 1979, p. 1059-1068. In French.

The guiding device for a heliostat for a several-MWe thermo solar power plant consists of a tetrahedral structure with indirect drive that permits a reduction in perturbing couples operating on the motors and helps achieve good wind stability. The focusing reflector consists of three elements obtained by attaching glass onto a honeycomb support. Focusing is achieved by regulation through a reference structure. P.T.H.

A79-33345 Thomson scattering measurements on ohmically heated plasmas in the JFT-2 tokamak. T. Matoba, A. Funahashi, T. Itagaki, K. Kumagai, T. Shoji, N. Suzuki, and T. Yamauchi (Japan Atomic Energy Research Institute, Tokai, Ibaraki, Japan). *Japanese Journal of Applied Physics*, vol. 18, Mar. 1979, p. 611-619. 11 refs.

Measurements were made on electron temperature and density profiles of ohmically heated hydrogen plasmas in the JFT-2 tokamak device by using Thomson scattering of light from a Q-switched ruby laser. The measured electron temperature ranged from 0.08 keV to 1.2 keV for electron densities of 2.0 times 10^{19} to the 12th/cm to 4.4 times 10^{19} to the 13th/cm. The temperature profile was found to have a rather sharp distribution in the central region. The electron temperature was found to vary linearly with the plasma current, and the ionic charge derived from the electron temperature and plasma conductivity decreased with the electron density. The experimental electron thermal conductivity in the central region was compared with the theoretical prediction that the electron thermal conductivity is much greater than the neoclassical electron thermal conductivity and less than about the dissipative-trapped electron thermal conductivity. (Author)

A79-33346 Confinement of ohmically heated plasmas in Heliotron D. S. Morimoto, K. Kondo, T. Mizuuchi, A. Iiyoshi, and K. Uo (Kyoto University, Uji, Japan). *Japanese Journal of Applied Physics*, vol. 18, Mar. 1979, p. 621-625. 13 refs.

Empirical laws for electron energy density and particle confinement time are derived for ohmically heated plasmas in Heliotron D. The empirical law for electron energy density suggests that the energy confinement of the electron is pseudoclassical. On the other hand, the particle confinement time shows the diffusion is neoclassical like in the plateau region. (Author)

A79-33379 Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford University, Stanford, Calif., March 27-29, 1978, Proceedings. Symposium sponsored by Stanford University. Edited by C. H. Kruger (Stanford University, Stanford, Calif.). Stanford, Calif., Stanford University, 1978. 361 p. \$20.

MHD power generation is discussed with reference to MHD coal combustion, open cycle processes, slag effects, and electrode wall materials. Consideration is also given to discharge and plasma effects, open cycle processes, and component design. B.J.

A79-33380 # Mechanistic modeling of pulverized coal combustion. D. B. Stickler and S. K. Ubhayakar (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. A.1.1-A.1.7. 8 refs. Contract No. EF-77-C-01-2519.

An analytical model developed to simulate an MHD coal combustor is presented which highlights the various physicochemical mechanisms of importance in this particular type of combustion process. The model, which breaks down into three major conceptual blocks (fluid dynamics, particle processes, and gas chemistry), is compared with experimental data from recent combustor tests. The versatility of the model in predicting behavior under different conditions is exemplified by a parametric study involving air preheat temperature, vitiated air temperature, size vs. burnout, etc. B.J.

A79-33381 # Coal combustor technology development. D. B. Stickler, F. E. Becker, J. W. Lothrop, R. DeSaro, S. K. Ubhayakar, and A. Ballantyne (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. A.2.1-A.2.8. 6 refs. Contract No. EF-77-C-01-2519.

The rate and efficiency of pulverized coal combustion have been measured under conditions appropriate to MHD system operation. Both a regenerative air heater system and vitiation based hot oxidizer source have been used with single element coaxial injection into plug flow tubular combustors. With air preheated to about 1700 K, 4 atm, HVAB coal at 70% minus 200 mesh is found to burn in about 30 msec at slightly rich conditions. Fuel utilization decreases, and heat loss increases, with increased fuel input. Measured particle temperature approximates 2400 K and appears to be controlled in part by endothermic heterogeneous char reactions. Gas temperature is inferred from NOx concentration to be 2700 K and from an energy balance as 2600 K under stoichiometric combustion conditions. Combustion chambers have been operated with stable slagging wall designs. The injector system used has operated as designed, without fouling or instability. Optimal MHD combustor thermal efficiency appears to be obtained using slightly fuel rich coal combustion conditions. (Author)

A79-33382 # Sensitivities of outputs to variations of inputs in MHD combustors. D. A. Rudberg and C. H. Dudding (Montana State University, Bozeman, Mont.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. A.3.1-A.3.6. 7 refs. Contract No. EF-77-C-01-2524.

The paper reports on the use of an internally adiabatic steady-state plug-flow combustor model designed to predict operating states of single-stage or two-stage pulverized-coal-fired combustors operating in the 1800-3000-K range, which is appropriate for MHD generators. Sensitivities of outputs to variations of inputs in MHD combustors are presented graphically. Output temperature, char burnout, electrical conductivity, and heat loss are shown as functions of a wide variety of input variations. B.J.

A79-33383 # A two-dimensional pulverized coal combustor model. M. R. Baer (Sandia Laboratories, Albuquerque, N. Mex.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. A.4.1-A.4.7. 7 refs. Research supported by the U.S. Department of Energy.

A numerical procedure is employed to examine the turbulent reactive flow field in an axial fired cylindrical combustor. Solution of the full 2-D elliptic partial differential equations is obtained with a second order closure model for turbulence. In addition, an eddy-breakup model is applied to characterize mixing controlled combustion. For the case of CO oxidation, predictions of species concentration distributions show good agreement with experiment. As such, the analysis is extended to treat the problem of pulverized coal combustion. This requires the addition of a devolatilization/diffusion controlled coal particle combustion in model when rapid mixing (or eddy-breakup) occurs. (Author)

A79-33384 # Behavior of eastern and western coals in fuel-rich reaction conditions. S. K. Ubhayakar, R. E. Gannon, and D.

B. Stickler (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. A.5.1-A.5.4, 7 refs. Contract No. EF-77-C-01-2519.

An experimental study of the gasification behavior of an eastern and of a western coal under conditions representative of two-stage MHD combustors or of high-energy gasifiers is described. The purpose of the study was to explore the relationship of coal rank to pyrolysis and heterogeneous char reactions as they affect requirements on combustor or gasifier design. The experiments were conducted in an entrained flow gasifier in which the entraining gases were the products of combustion simulating fuel-rich combustor conditions or MHD exhaust. B.J.

A79-33385 # Cyclone and fluidized bed combustion concepts for coal fired open cycle MHD. S. Omori, J. Hnat (General Electric Co., Space Div., Philadelphia, Pa.), J. Bazan, and B. Biswas (Foster-Wheeler Development Corp., John Blizard Research Center, Livingston, N.J.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. A.6.1-A.6.8, 21 refs. Contract No. EF-77-C-01-2613.

Predicted performances of fluidized bed and cyclone combustion schemes were compared as part of a recent conceptual design study of a sub-scale (250 MWt), open-cycle MHD Engineering Test Facility (ETF). Both combustion concepts were two-stage gasification/combustion systems designed for high slag/ash rejection with predictions for slag/ash rejection being greater than 99% and 90% for the fluidized bed and cyclone concepts respectively. For the particular two-stage combustion systems evaluated, analyses indicated that for the same thermal input, maximum air preheat temperature, and exit pressure, the cyclone combustion scheme had slightly better thermodynamic performance than the fluidized bed scheme. When integrated into combined cycle (MHD topping, steam bottoming) power plants, the overall plant efficiencies utilizing each of these combustion concepts differed by about 2 percentage points with the cyclone concept yielding the higher plant efficiencies. Aside from thermodynamic performance, considerations of subsystem interactions, practical plant operation, reliability and system design flexibility favor the fluidized bed concept over the cyclone design for the intended purpose of the ETF. (Author)

A79-33386 # Open-cycle disk generator studies. J. E. Klepeis (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. B.1.1-B.1.5, 5 refs. Research supported by the U.S. Department of Energy.

A theoretical correlation is presented to explain the enthalpy extraction performance of two radial-flow, open-cycle disk channels: Disk-1 and Disk-2. The channels were driven by a large shock tube, and were operated at flow conditions that simulated coal-firing at high air preheat. Magnetic fields up to 4.5 tesla were applied. Disk-2 performed twice as well as Disk-1 and achieved an enthalpy extraction of 15% at an estimated isentropic efficiency of greater than or equal to 55%. Application of the disk concept to commercial, open-cycle, coal-fired MHD power generation is discussed. (Author)

A79-33390 # Compositional modeling of MHD channel slag, with preliminary vapor pressure data. E. R. Plante and L. P. Cook (National Bureau of Standards, Washington, D.C.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. C.1.1-C.1.6, 14 refs. Research supported by the U.S. Department of Energy.

A79-33391 # Fluid mechanics and thermal behavior of MHD channel slag layers. M. E. Rodgers and C. H. Kruger (Stanford University, Stanford, Calif.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. C.2.1-C.2.6, 8 refs. Research supported by the Electric Power Research Institute.

Duct wall slag films are investigated experimentally for two coal types and several operating conditions. Surface temperature, layer thickness, and slag layer run-off are measured. The effect of substrate temperature, ash feedrate, potassium, and plasma velocity are studied. Run-off data are consistent with deposition models. With slag properties inferred from available published data, measured and calculated thickness and surface temperature are in general agreement. (Author)

A79-33392 # Discharge characteristics of slagging metal electrodes. J. K. Koester and R. M. Nelson (Stanford University, Stanford, Calif.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. C.3.1-C.3.9, 6 refs. Research supported by the Electric Power Research Institute.

The behavior of slag coated electrodes under applied transverse discharges at MHD generator duct conditions was investigated for both arc mode and diffuse mode operation. Slag layers were found to have substantial ionic conductivity with iron and potassium as the mobile species. Severe anodic polarization was observed for all materials other than low carbon steel. The 'plating out' of iron in the slag layer was observed at the cathode wall. The arc discharge through slag was studied for several electrode materials including platinum clad copper. Arc voltage drop, size, distribution, and surface temperature were determined. In situ slag layer resistance was measured as a function of current and spurious low values of axial resistance were observed at the cathode wall. (Author)

A79-33393 # Computer modeling of the effects of coal ash chemistry on the performance of MHD generators. V. Yousefian, J. Wormhoudt, C. E. Kolb (Aerodyne Research, Inc., Center for Chemical and Environmental Physics, Bedford, Mass.), M. Martinez-Sanchez, and J. L. Kerrebrock (Aerodyne Research, Inc., Center for Chemical and Environmental Physics, Bedford; MIT, Cambridge, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. C.4.1-C.4.6, 17 refs. Contract No. EX-76-C-01-2478.

Plasma chemical effects due to vapor and liquid phase ash-derived species could have a major influence on the plasma conductivity achievable in direct coal-fired MHD generators. A new computer program called the PACKAGE (Plasma Analysis, Chemical Kinetics And Generator Efficiency) code has been developed to perform calculations of coal combustion plasma compositions and the effects of these compositions on plasma conductivity and generator efficiency. The negative ion species sampled from a laboratory plasma produced by methane augmented combustion of Montana Rosebud coal with preheated air and potassium carbonate seed are compared with PACKAGE code predictions. (Author)

A79-33394 # MHD slag electrical conductivity studies. R. Pollina and R. Larsen (Montana State University, Bozeman, Mont.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. C.6.1-C.6.6, 19 refs. Contract No. EF-77-C-01-2524.

A closed-form mathematical expression for the electrical conductivity of the slag layer adhering to the walls of a MHD generator has been developed. The mathematical expression, a function of temperature and iron content, applies to a limited temperature range and is accurate to about 10%. It was developed on the basis of studies with a Montana coal ash. A similar curve fitting may also be possible for seeded slag over a limited temperature range. Additions of K₂CO₃ to the coal ash resulted in substantial changes in

conductivity at temperatures below 1650 K. Phase transitions within the slag complicate the conductivity assessments. J.M.B.

A79-33395 # Thermionic emission properties of some synthetic coal slags. J. Anderson, W. F. Anderson, M. Wilson, and G. J. Lapeyre (Montana State University, Bozeman, Mont.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. C.7.1-C.7.5. 5 refs. Contract No. EF-77-C-2524.

Measurements of the thermionic emission into vacuum have been made for three high silica (up to 60% by weight SiO₂) synthetic slags. The slags contained respectively 0%, 10%, and 30% K₂O by weight and the measuring temperatures were in the range 1400-1800 K. In contrast to the usual effects in thermionic emitters, the potassium in the slag appeared to play no role in reducing the work function. Possible reasons for such a result are discussed and it is suggested that the large thermionic emission currents actually observed in MHD channels depend on the interaction of the surface with potassium in the ambient plasma. (Author)

A79-33396 # Electrode development for coal fired MHD generators. A. Demirjian, S. W. Petty, and A. Solbes (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. D.1.1-D.1.6. Research supported by the U.S. Department of Energy.

The paper focuses on two key aspects of the electrode wall behavior in slagging linear MHD channels. The first problem is related to electrode life-time and anodes in particular. The electrode design principle is based on the utilization of massive water cooled copper current lead outs, capped with oxidation resistant materials to minimize anodic erosion. The results of numerous cap material tests, conducted in the Mark VI facility, are discussed in detail. The second aspect characteristic of the operation of slagging channel is the development of cathode wall non-uniformities. It is shown that these are related to slag layer leakage and the salient features of the phenomenon are analyzed in detail. (Author)

A79-33397 # Insulator performance and anode recession rate in a direct coal fired cold copper diagonal conducting wall MHD generator. M. S. Beaton, M. H. Scott, Y. C. L. Wu, J. B. Dicks, Jr., J. W. Muehlhauser, W. L. Holt, and H. D. James (Tennessee University, Tullahoma, Tenn.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. D.2.1-D.2.6. 11 refs. Contract No. EX-76-C-01-1760.

A79-33398 # Electrochemical corrosion of MHD electrodes in slags. L. H. Cadoff, B. R. Rossing, and H. D. Smith (Westinghouse Research and Development Center, Pittsburgh, Pa.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. D.4.1-D.4.12. 10 refs. Contract No. EX-76-C-01-2248.

The understanding of electrochemical corrosion reactions has been shown to be critically important to the selection of electrode materials for MHD channels operating under semi-hot wall slagging conditions. In this work, electrochemical screening tests have been conducted at various temperatures and current densities on a variety of candidate electrode materials (i.e., MgCr₂O₄, Pt, Fe, 3MgAl₂O₄ : 1Fe₃O₄, MoSi₂, LaCrO₃) in an eastern USA coal slag. Several types of test cells designed to simulate electrochemical reactions in 'virgin' slag and in slag that becomes saturated with electrode/slag reaction products will be described. The chemistry, mechanisms and kinetics of electrode/slag reactions have been evaluated and will be discussed in detail. Important electro-chemical reactions include slag electrolysis, preferential transfer of aggressive ion species in the slag to the cathodes and anodes, chemical reactions of electrodes with slag and

with the products of the electrolysis of the slag, and cavitation/erosion of the anodes. The implications of these results on selecting electrode materials and in selecting conditions for operating an MHD channel under slagging conditions are discussed. (Author)

A79-33399 # Electrochemical studies of MHD channel electrode materials in molten potassium salt and coal slags. D. D. Marchant, C. W. Griffin, and J. L. Bates (Battelle Pacific Northwest Laboratories, Richland, Wash.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. D.5.1-D.5.5. Contract No. EY-76-C-06-1830.

Laboratory tests were conducted on some potential MHD electrode materials to evaluate their electrochemical reactions. Electrode materials 0.25Fe₃O₄.0.75MgAl₂O₄(FMAS), La_{0.95}Mg_{0.05}CrO₃ (LMC), and 0.10Tb₄O₇.0.9HfO₂ (THF) were tested in both liquid and vapor K₂CO₃ and K₂SO₄, as well as potassium seed/slag. Tests have confirmed that electrochemical reactions are substantially accelerated in these materials when used as electrical conductors. Electrochemical effects are functions of electrolyte composition (especially Fe and K), temperature, and electric current density. (Author)

A79-33400 # Thermal properties of MHD electrode materials. J. L. Bates and D. D. Marchant (Battelle Pacific Northwest Laboratories, Richland, Wash.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. D.6.1-D.6.7. Contract No. EY-76-C-06-1830.

The thermal conductivity and thermal expansion of a number of oxide electrodes and insulators of interest to MHD have been measured from 400 to 1850 K. The results are summarized and discussed in terms of fabrication, microstructure, and phase changes. Arc plasma sprayed, sintered, and hot pressed materials are discussed. Equations for the thermal conductivity and the thermal expansion coefficients as functions of temperature are given where possible. (Author)

A79-33401 # Axial interelectrode breakdown in MHD channels. N. N. Baranov, D. K. Burenkov, Iu. L. Dolinskii, A. D. Izerov, V. V. Kirillov, I. I. Klimovskii, V. I. Kovbasiuk, B. Ia. Shumiatskii, A. S. Tikhotskii, and G. L. Uspenskaia (Akademiia Nauk SSSR, Nauchno-Issledovatel'skii Institut Vysokikh Temperatur, Moscow, USSR). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. E.1.1-E.1.7. 5 refs.

Results are reported for experimental studies of interelectrode breakdown in a Hall field in the U-02 installation and the U-25 power plant. It is found that Hall breakdown in Faraday channels can take place at both the anode and cathode walls, that conditions for breakdown are more favorable at the anode wall, and that breakdown there occurs at lower interelectrode voltages and electrode currents. The experiments in the U-02 installation confirm the possibility of two types of breakdown: 'fast' breakdown through the plasma and 'slow' breakdown on insulator surfaces. The voltage for 'fast' breakdown is shown to depend significantly on the width of the interelectrode insulator. It is concluded that intense Faraday arcs on the electrodes must be excluded in order to prevent damage due to interelectrode breakdown. F.G.M.

A79-33402 # Transient behavior of the fluid and electrical properties in the turbulent boundary layer of an MHD channel. A. J. Russo, F. G. Blottner, and K. J. Touryan (Sandia Laboratories, Albuquerque, N. Mex.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings.

Stanford, Calif., Stanford University, 1978, p. E.2.1-E.2.7. 11 refs. Research supported by the U.S. Department of Energy.

The details of the electrical and flow development near the electrodes and insulators with a suddenly applied current is investigated by solving the governing equations numerically. In order to make the solution tractable, a limited region of the channel is considered over two electrodes and the appropriate boundary conditions for the solution domain are developed. The steady Maxwell equations are solved with a direct solution procedure while the unsteady boundary layer equations are solved with an implicit finite-difference marching scheme. Solutions are presented for both an equilibrium and nonequilibrium electrical conductivity model. The results show the importance of modeling the conductivity properly and the necessity of accurately solving for the electrical properties. (Author)

A79-33406 # The U-25B facility for studies in strong magnetohydrodynamic interaction. V. A. Kirillin, A. E. Sheindlin, A. V. Karpukhin, V. I. Maksimenko, S. A. Pashkov, D. S. Pinkhasik, N. P. Privalov, V. D. Semenov, V. S. Sidorov, and Iu. D. Sokirko (Akademiia Nauk SSSR, Nauchno-Issledovatel'skii Institut Vysokikh Temperatur, Moscow, USSR). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. F.1.1-F.1.12.

The general layout and main components of the U-25B facility, which will provide a rational basis for the design of commercial MHD power-plant components, are described. This facility consists of a bypass loop inserted between the air preheaters and the seed recovery system of the U-25 pilot plant. The main components of the power flow train are discussed, including the combustor, mass-flow channel, and power extraction system. Attention is also given to the design, fabrication, and commissioning of the superconducting magnet system, the diffuser, the electrical insulation, the diagnostic instrumentation, and the control system. Results of the first test of the U-25B facility are examined, and planning for subsequent tests is outlined. F.G.M.

A79-33407 # Diagonal frame RM channel of the U-25 power plant. A. E. Barshak, V. A. Bitiurin, A. E. Buznikov, A. V. Karpukhin, V. I. Kovbasiuk, V. I. Maksimenko, S. A. Medin, and S. I. Pishchikov (Akademiia Nauk SSSR, Nauchno-Issledovatel'skii Institut Vysokikh Temperatur, Moscow, USSR). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. F.2.1-F.2.9. 6 refs.

Design of the diagonal-frame RM channel for the U-25 power plant is described and some initial test results are given. The RM channel is designed for power output of about 10 MW with mass flow rate of 50 kg/sec, 40% oxygen air enrichment, 2 T magnetic field, and 2.5 V Hall voltage. A model for the gas dynamics of the channel is developed. Arc damage test results are presented. P.T.H.

A79-33408 # Evaluation of the expected diffuser performance for a large MHD generator. T. R. Brogan (MEPPSCO, Inc., Boston, Mass.), J. J. Idzorek (Fluidyne Engineering Corp., Minneapolis, Minn.), and D. Swallow (Maxwell Laboratories, Inc., Woburn, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. F.3.1-F.3.6. Research sponsored by the Argonne National Laboratory.

The paper describes an experimental program intended to evaluate the expected performance of the diffuser for the MHD generator being designed and built by the U.S. for test in the U.S.S.R. U-25 MHD Facility. The measured parameters include overall pressure recovery, static pressure distribution, presence or absence of separation and transitory stall, and exit dynamic pressure surveys, both steady and transitory. The test program demonstrated that nozzle blockage can be conveniently established by tailoring the

length of a duct of uniform cross section. Both blockage and diffuser performance are observed to be independent of wall-to-gas stream enthalpy ratio. A diffuser with a divergence half-angle of 2 deg 05 min with an assumed recovery coefficient of 0.45 is selected for fabrication. S.D.

A79-33409 # Detailed characterization of MHD generator operating parameters. R. Kessler and A. Solbes (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. F.4.1-F.4.8. Research supported by the U.S. Department of Energy.

Experiments were conducted to investigate detailed operating characteristics of combustion-driven slugging MHD generators. Performance characteristics of two different generators are compared. One generator was built with conventional flat electrode walls, and the other had V-shaped electrode walls. Both generators had peg-type insulator walls which were used for detailed electrical diagnostics. The generators had identical lofting and both were operated over a similar range of gas conditions, magnetic-field intensities, and electrical loading. The V-wall generator had higher voltage drops at both electrode walls and produced less power at given values of gas electrical conductivity and magnetic field. Detailed heat-transfer measurements were made in the flat-wall channel under both power-generating and non-power-generating conditions. Under power-generating conditions, heat transfer to both cathode and anode walls increased significantly. Heat transfer was measured to an electrode pair that was not drawing current but was located downstream of a large number of electrodes that were drawing current. The open-circuited electrode pair experienced increased heat flux compared with the case in which the upstream electrodes drew no current. (Author)

A79-33410 # Development of a compact, lightweight high performance 30 MW MHD generator system. O. K. Sonju, D. W. Swallow, D. E. Meader, H. Becker (Maxwell Laboratories, Inc., Woburn, Mass.), R. V. Burry, A. W. Huebner (Rockwell International Corp., Rocketdyne Div., Canoga Park, Calif.), and R. F. Cooper (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. F.5.1-F.5.10. 7 refs. Contract No. F33615-76-C-2104.

This paper describes the current phase of a multiphase program to design, construct, and test a lightweight, high power prototype transportable MHD generator system. The main purpose of this phase is to demonstrate the feasibility of the hot gas flow train components of high performance, lightweight design. In the present program significant advances in terms of such parameters as combustor heat release density, combustion efficiency, channel power density and energy extraction rates are made. The combustion system has a high performance, 160 element injector and the channel was constructed using lightweight electrode frames and a high strength, lightweight glass-fiber wound composite outer wall structure. The results of this phase of the development program that are reported in this paper are part of an overall advancement of the state-of-the-art of compact, lightweight high performance MHD channels and diffusers for transportable burst power MHD generator systems. (Author)

A79-33411 # Design and operation of the Westinghouse electrode systems test facility /WESTF/. J. A. Dillmore, J. Lempert, S. J. Schneider, and E. W. Frantti (Westinghouse Research and Development Center, Pittsburgh, Pa.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. G.1.1-G.1.8.

The paper describes the design and operation of a 1.0 MW(thermal) test facility, along with the techniques used to evaluate

the electrical and thermal performance of MHD electrode systems under simulated clean or coal fired MHD generator conditions. An electrode system is defined as the basic generator elements which allow for current transfer, electrical insulation and thermal management. One-dimensional momentum and energy equations including friction and heat loss terms are used to predict the thermal conditions in the test channel, where a Mollier diagram of the products of combustion of toluene and air is used for fluid properties. Five tests on cold copper electrode systems and four tests on hot ceramic electrode systems have been run in the facility since June 1977. Thermal design of test channels based on one-dimensional duct flow analysis is proven by test results to accurately predict the desired test conditions. The test facility operates very reliably as a long-duration device for the screening of candidate electrode materials. S.D.

A79-33415 # Properties and test results of super-hot wall electrode materials. W. R. Cannon, M. Yoshimura, J. Mizusaki, T. Sasamoto, R. L. Pober, J. Hart, H. K. Bowen, and J. F. Louis (MIT, Cambridge, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. G.5.1-G.5.6. 8 refs.

Studies in the laboratory and in an MHD channel simulator have been made to relate chemical stability to performance. New materials have been investigated for use as hot electrodes (T greater than 1700 C) from the ternary $\text{LaFeO}_3\text{-SrZrO}_3\text{-SrFeO}(3-x)$ and from the binary system $\text{La}_{0.75}\text{Sr}_{0.25}(\text{Fe}_{0.5}\text{Cr}_{0.5})\text{O}_3\text{-SrZrO}_3$. Phase diagrams are presented, as well as electronic-conductivity and phase-stability data for several compositions. A quantitative formula has been developed to determine chemical potential of the elements in the electrode or slag and is based on physical properties data and operating conditions. This expression allows for the prediction of the stability of the materials due to electrochemical effects. (Author)

A79-33418 # Performance of a closed cycle MHD generator with molecular impurities. M. Zlatanovic, A. Veeffkind, and L. H. T. Rietjens (Eindhoven, Technische Hogeschool, Eindhoven, Netherlands). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.2.1-H.2.6. 12 refs.

The influence of small amounts of molecular impurities on the properties of a noble gas alkali MHD plasma has been investigated theoretically and experimentally. The theory has been used to calculate the apparent electrical conductivity, the electron temperature, the electron number density and the vibrational temperature in a stationary, homogeneous argon-cesium MHD plasma with addition of nitrogen. The agreement between theory and experiment was found to be reasonable. Two kinds of molecular impurities, N_2 and CO_2 , have been studied experimentally as the contaminants in a shock tube MHD generator. In two series of experiments, one at low and one at high stagnation temperature, the concentration of N_2 was varied over the range 0-2% and the concentration of CO_2 over the range 0-0.4%. At an inlet stagnation temperature of 2000 K and a magnetic induction of 3 T the critical amount of CO_2 with respect to the power production appeared to be 100 ppm. For N_2 this critical amount is 3000 ppm. (Author)

A79-33419 # Noble gas MHD generator experiments at low stagnation temperatures. A. Veeffkind, W. M. Hellebrekers, L. H. T. Rietjens (Eindhoven, Technische Hogeschool, Eindhoven, Netherlands), and C. A. Borghi. In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.3.1-H.3.7. 11 refs.

Results are presented for an experimental study of a cesium-seeded argon MHD generator at stagnation temperatures equal to and below 2000 K, which was carried out in an MHD shock-tunnel facility. The discharge is studied in detail with the aid of an

image-converter streak camera in order to obtain an extensive set of experimental data on discharge structures at different values of magnetic induction and different stagnation temperatures. Two models for the plasma inhomogeneities, a layer model that includes a streamer angle and a model with isotropic inhomogeneities, are used to predict the electrode currents and electric power output from the measured values of electron density and temperature, including their fluctuations. The results show that: (1) no power is produced at stagnation temperatures below 1700 K; (2) the maximum enthalpy extraction at an inlet stagnation temperature of 2000 K is 11.5%; (3) the discharge structure is inhomogeneous under all the experimental conditions considered; and (4) there is a strong correlation between the electrode currents and radiation at the same position in the generator channel. F.G.M.

A79-33420 # Design of the Eindhoven 5 MW thermal MHD blow down experiment. J. H. Blom, W. J. M. Balemans, H. J. Flinsenberg, D. J. Kleijn, P. Massee, W. F. H. Merck, and L. H. T. Rietjens (Eindhoven, Technische Hogeschool, Eindhoven, Netherlands). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.4.1-H.4.6. 12 refs. Research supported by the Department of Economic Affairs of Netherlands.

A 5 MW closed cycle MHD blow down experiment has been designed. The facility is rated to deliver an argon mass flow of 5 kg/s with a temperature of 2000 K and a pressure of 7 bar. A cesium aerosol is injected upstream of the generator to provide a maximum seed ratio of 0.1%. The total flow time is one minute. A cryogenic magnet provides a magnetic field of 5 T during 11 s. The argon gas is heated with a clean gas fired regenerative heat exchanger. The generator channel will operate in a heat sink mode and is designed for 20% enthalpy extraction. (Author)

A79-33421 # Power generation experiments of a linear MHD generator with fully ionized seed. S. Shioda, H. Yamasaki, and Y. Masuhara (Tokyo Institute of Technology, Tokyo, Japan). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.5.1-H.5.5. 6 refs.

Power generation experiments with small seed fractions (0.00001-0.0001) are carried out with a view to show the recovery of effective plasma conductivity in a linear generator and to demonstrate the possible operation of a nonequilibrium linear Faraday generator with fully ionized seed. The Ar/K working gas is heated by a shock tube, and the seed concentration is controlled from the monitored data of the absorption of the 7699-A potassium line at the low-pressure chamber of the shock tube. The pressure, temperature, and seed concentration are measured in each experiment by a semiconductor pressure gage, the line reversal method and absorption of the potassium spectral line at the stagnation region located before the nozzle entrance. The results confirm the possible operation of a linear MHD generator with fully ionized seed and the increase of isentropic efficiency of a closed cycle inert gas MHD generator. S.D.

A79-33422 # Two-phase LMMHD mixer-development experiments. G. Fabris, P. F. Dunn (Argonne National Laboratory, Argonne, Ill.), and J. C. F. Chow (Argonne National Laboratory, Argonne, Illinois, University, Chicago, Ill.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.6.1-H.6.6. 9 refs. Research sponsored by the U.S. Department of Energy and U.S. Navy.

Results are presented for experiments designed to evaluate the fluid mechanical performance of various two-phase LMMHD mixer designs. Flow visualization studies and local flow-characterization measurements are made. Research findings led to the conceptual design of a two-phase LMMHD mixer that ensures the generation of

small bubbles, prevents the formation of gas slugs and separated regions, and favors the stabilization of a homogeneous foam flow.

S.D.

A79-33423 # An experimental investigation of rotating-drum separators for liquid-metal MHD applications. C. S. Lenzo, P. V. Dauzvardis, and R. G. Hantman (Argonne National Laboratory, Argonne, Ill.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.7.1-H.7.5. Navy-supported research.

One of the key components in closed-cycle two-phase-flow MHD power systems is an effective and efficient gas-liquid separator-diffuser. Based on an assessment of present technology, it was decided to study the characteristics of a rotating-drum type of separator, and a multitask research and development program was initiated within an overall liquid-metal MHD research program. The first task, now completed, centered on the investigation of single-phase flow (liquid) deposited by a flow nozzle on the inner surface of freely rotating cylinders or drums of 423 mm and 282 mm diam. The tests were designed to study: the recovery of energy in the liquid layer deposited on the drum; the torque transmitted to the drum by the liquid as the result of shear stress between the liquid and the drum surface; the characteristics of the liquid layer; and the effects of drum size, nozzle shape and orientation, and nozzle velocity. The test results showed that a stable liquid film was formed on the drum and that the kinetic energy of the liquid layer was high enough to be potentially useful in two-phase-flow MHD power systems. (Author)

A79-33424 # Dynamics of a free-piston Diesel-MHD generator. V. A. Bashkatov, Iu. M. Kirillov, S. S. Safonova, E. M. Shelkov, and E. E. Shpilrain (Akademiia Nauk SSSR, Nauchno-Issledovatel'skii Institut Vysokikh Temperatur, Moscow, USSR). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. H.8.1-H.8.7. 6 refs.

Direct conversion of heat to electricity by a free-piston system consisting of Diesel drive and two conducting liquid metal MHD generators is analyzed. The dynamic characteristics of the system are calculated on the basis of a boundary value problem for the equation of motion of the centers of mass of the moving parts. It is shown that the efficiency of a free-piston Diesel-MHD generator can reach 34-36%. P.T.H.

A79-33425 # Consolidation and local control of power in an MHD generator. A. Lowenstein (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. I.1.1-I.1.6.

The operating characteristics of two circuits for the consolidation and control of power out of the MHD generator have been studied both analytically and experimentally in tests on the Avco Mark VI. The first circuit utilizes the principle of inductive coupling of electrode currents, which was first suggested by Rosa. The second circuit uses a novel scheme whereby a capacitor provides the required isolation between two electrodes, while power from the two electrodes is delivered to a common point. Two methods of forming cascaded networks for handling a multiple of electrodes using either of these two consolidation elements are also described. (Author)

A79-33426 # Developments in electrodes and power conditioning systems for open-cycle MHD generators. B. Zauderer, A. P. Coppa, M. J. Noone, L. DeDominicis, A. Gatti, D. A. Rogers, E. Feingold, and B. Faust (General Electric Co., King of Prussia, Pa.).

In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. I.2.1-I.2.8. 15 refs.

A79-33428 # Transient response of MHD/steam bottoming plants with phased air preheaters and heat capacitor. R. Johnson (Montana State University, Bozeman, Mont.) and T. Robles (Tennessee Technological University, Cookeville, Tenn.). In: Symposium on the Engineering Aspects of Magnetohydrodynamics, 17th, Stanford, Calif., March 27-29, 1978, Proceedings. Stanford, Calif., Stanford University, 1978, p. I.4.1-I.4.6. Contract No. EF-77-C-01-2524.

A detailed dynamic model of the steam bottoming portion of an MHD/steam plant which has been programmed is briefly described. The program is suitable for investigation of a variety of transients effecting the bottoming portion of combined MHD/steam plants including the response of electrical and thermal changes on air preheater cycling temperatures and seed condenser performance. When combined with dynamic topping plant programs at MSU and elsewhere the overall transient behavior of MHD/steam plants may be studied including proposed control algorithms. After a brief discussion of the model, results are presented for two case studies which are typical of those expected as a consequence of MHD topping cycle fault or rapid load change in a 250 MWT ETF power plant. (Author)

A79-33690 # Effect of microwave radiation on the volt-ampere characteristics of superconducting bridges of variable thickness (O vliianii SVCh izlucheniia na VAKh sverkhprovodiashchikh mostikov peremennoi tolshchiny). V. N. Gubankov, V. P. Koshelets, and G. A. Ovsiannikov (Akademiia Nauk SSSR, Institut Radiotekhniki i Elektroniki, Moscow, USSR). *Zhurnal Tekhnicheskoi Fiziki*, vol. 49, Apr. 1979, p. 832-838. 14 refs. In Russian.

The paper examines data on the temperature and field dependencies of the photodetection response (in narrowband and broadband detection modes) of thin-film Josephson microbridges subjected to centimeter-wave and millimeter-wave radiation. The effects of superconductivity induced in the bridges by microwave radiation and by dc current upon the response is considered. Operation in the heterodyne detection mode eliminates these effects and leads to an increase in the differential resistance of the bridges. B.J.

A79-33748 * Commercial prospects for extraterrestrial materials. D. R. Criswell and R. D. Waldron (Lunar and Planetary Institute, Houston, Tex.). *Journal of Contemporary Business*, vol. 7, no. 3, 1978, p. 153-169. 18 refs. Contract No. NSR-09-051-001.

Prospects for using lunar resources as materials for spaceborne construction are examined. The use of lunar construction materials is considered economically justifiable in the case of such large scale projects as space power stations (SPS). A proposed scenario for the acquisition and space processing of lunar materials involves the use of space shuttles to deliver an assembly base to earth orbit, where a solar powered mass driver reaction engine rocket is assembled and used to bring sections of a lunar base from low earth orbit to the moon. The rocket would then be positioned at the L2 equilibrium point in order to catch lunar soil propelled into space by a mass driver and bring it to the assembly base for chemical processing. Cost factors would be comparable to those of the terrestrial deployment of the first SPS, and such a project could be in operation before the end of the century. A.L.W.

A79-33752 The role of the local authority in waste reclamation. J. R. Holmes (P. D. Pollution Control, Ltd., Aylesbury, Bucks., England). *Conservation and Recycling*, vol. 2, no. 2, 1978, p. 145-162. 14 refs.

The broad alternatives for waste disposal currently available to public authorities are examined, taking into account economic, environmental and technological factors. The most economical

method is shown to remain sanitary landfill, which could be easily accommodated in the space created by surface mineral extraction. The recovery of useful materials from refuse at the collection point has been found to be limited in practice, although paper recovery at the collection point is shown to be economically feasible. Recovery techniques at the point of disposal considered include domestic waste incineration to generate heat and electricity and separation processes for the recovery of tin cans and nonferrous metals. Waste transfer stations are considered as economical sites for reclamation of ferrous metals and supplemental fuels, in addition to functioning as central facilities in waste transport and treatment. A.L.W.

A79-33753 The microbial production of methane from the putrescible fractions of sorted household waste. N. W. Le Roux and D. S. Wakerley (Ministry of Technology, Warren Spring Laboratory, Stevenage, Herts., England). (*World Recycling Congress, 1st, Basel, Switzerland, Mar. 6-9, 1978.*) *Conservation and Recycling*, vol. 2, no. 2, 1978, p. 163-179. 28 refs.

Representative mixed samples of the putrescible fractions of sorted household wastes have been fermented at 30 C to produce methane. Fermentation vessels for semicontinuous operation were designed to enable glass, grit and other heavy solids and also floating plastic material to be easily removed. For optimum gas yields water had to be added to the putrescible material to maintain the solids content of the fermentations at less than 9% w/w. In one test liquor recovered by settlement from digested sludge was used successfully in place of water. No requirement for additional nitrogen or other mineral salts could be demonstrated. The highest yield of gas in the semicontinuous tests was 0.307 cu m/kg dry weight of feedstock. This was equivalent to a gas yield of 0.48 cu m/kg fermentable material in the fractions used. The composition of the gas was 65-70% methane plus 30-35% CO₂. In limited temperature studies at 30, 34 and 36 C the highest gas yields were obtained at 36 C. An economic assessment of the process as it might at present be applied to a refuse sorting plant concluded that the process would be uneconomic. However, if a market for the digested sludge could be found this could alter the economics appreciably. (Author)

A79-33754 The use of anaerobic digestion for the treatment and recycling of organic wastes. D. Hawkes, R. Horton (Polytechnic of Wales, Pontypridd, Wales), and D. A. Stafford (University College, Cardiff, Wales). (*World Recycling Congress, 1st, Basel, Switzerland, Mar. 6-9, 1978.*) *Conservation and Recycling*, vol. 2, no. 2, 1978, p. 181-195. 19 refs.

The recycling of natural organic wastes by means of anaerobic digestion produces methane, a premium fuel, as well as a protein rich residue, whilst at the same time reducing the pollution normally associated with such waste. The microbial process requirements impose engineering design constraints which are discussed in some detail. Figures from a simulation study are used to illustrate the effects of varying certain parameters. The paper concludes by looking at ways in which the process may be made more economic and gives typical results obtained from pilot plants operating at the Polytechnic of Wales site. (Author)

A79-33763 Complementary nature of wind and solar energy at a continental mid-latitude station. E. S. Takle and R. H. Shaw (Iowa State University of Science and Technology, Ames, Iowa). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 103-112. 8 refs. Research supported by the Iowa Energy Policy Council.

Daily values of solar and wind energy have been used (1) to study renewable energy availability at various times of year, (2) to test the level of persistence for inferences about the practicality of energy storage and, (3) to examine the complementary behavior of these two daily time series on both seasonal and daily bases. Results for the station studied (central Iowa) show a bimodal distribution for winter solar energy, whereas non-winter solar and wind (all seasons) show unimodal distributions. Wind and solar energy were observed to be highly complementary on an annual basis, but only slightly complementary on a daily basis. (Author)

A79-33764 Modelling of a domestic wind power system including storage. A. W. Bogle, J. T. McMullan, R. Morgan, and R. B. Murray (Ulster, New University, Coleraine, Northern Ireland). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 113-127. 17 refs.

A simulation analysis is presented of domestic heating by a wind power system including storage at a location 54 degrees 39 sec N, 6 degrees 13 sec W (Aldergrove, Northern Ireland). A simple theoretical model is constructed comprising a house of specified dimensions and heat loss characteristics, an aerogenerator and a thermal store. The data base used is a magnetic tape of hourly wind speed and air temperature readings taken at Aldergrove meteorological station during 1949-75. The results suggest a measure of optimization between store capacity and generator rating based on technical considerations alone, and a simple economic optimization is also presented. (Author)

A79-33765 Ammonia dissociation for solar thermochemical absorbers. O. M. Williams and P. O. Carden (Australian National University, Canberra, Australia). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 129-142. 13 refs.

A prototype ammonia dissociator has been constructed and operated over a wide variety of conditions, and its performance has been examined in relation to solar thermochemical absorber operation. High values of energy storage efficiency approaching unity are obtained for high values of reaction extent, corresponding to the use of high activity ammonia dissociation catalysts. There is a need for further development of such catalysts designed specifically for solar absorber operating conditions. It is shown that in order to make optimum use of the available catalyst volume, the power density profile and specific absorber design should be matched to give an essentially isothermal temperature profile along the catalyst chamber length. There is potential for a solar thermochemical absorber based on ammonia dissociation to be constructed using simple tube technology and thus within the severe cost constraints associated with solar absorber design. (Author)

A79-33766 The cost of hydrogen from coal. E. T. Kim, H. R. Moore, and R. I. Kermode (Kentucky, University, Lexington, Ky.). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 143-155. 17 refs. NSF Grant No. AER-73-0359-A02.

Isolation of the hydrogen and oxygen plants from the rest of the liquefaction complex, combined with appropriate transfer costs for all utilities and raw materials has been used to estimate the value of hydrogen. For the five alternatives, minimum cost hydrogen is produced by gasification of coal at 1000 psia. 500 psia gasification of coal yielded slightly more expensive hydrogen; however, on an equivalent mole basis of hydrogen, they were virtually the same. As would be expected, the cost of coal, discount cash flow rate and method of costing supplemental fuel needs were the primary variables affecting the cost of hydrogen. Hydrogen cost ranged from \$0.847/1000 standard cubic feet to \$2.986/1000 standard cubic feet. (Author)

A79-33767 Design and experimental testing of a fully-submerged model wave-power convertor. G. F. Knott and J. O. Flower (Sussex, University, Brighton, England). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 157-172. 8 refs. Research supported by the Science Research Council.

A new form of wave-power convertor is described which operates entirely beneath the water surface. Its operating principles are derived from theories relating to immersed cylinders which predict that a substantial proportion of incident wave-power can be absorbed by such bodies if they are constrained to respond to the waves in a prescribed way. Here, a series of discrete pulsating sources distributed around the surface of a stationary cylindrical body are used to approximate the necessary bodily motion. A one-hundredth scale model has been built and tested in a wave-tank, and the results of these experiments are presented. They indicate that under optimum operating conditions most of the incident wave-power is absorbed by the device. However, little of this power appears as useful work owing to the frictional losses inherent in such a

small-scale model. Further analysis of the data estimates the extent of the losses, and after taking these into account figures are arrived at for the optimal operation of the model in loss-less condition. This paper concludes with a discussion of the prospects for further development. (Author)

A79-33768 **Measurement of the performance of domestic air-to-air heat pumps.** R. K. Cattell (Building Research Establishment, Watford, Herts., England). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 181-187.

A facility has been constructed in which heat pumps can be tested over the whole range of conditions under which they will be used. This is achieved by installing the heat pump in an insulated chamber provided with means of heating and humidification and by using its own energy extraction to provide cooling and dehumidification of the chamber. By using appropriate control systems the conditions inside the chamber may be set at any particular value within the working range of the heat pump required. The facility is described together with the instrumentation and attention is given to problems of measuring heat transport in air streams. B.J.

A79-33769 **Performance of magnetohydrodynamic generator in the inlet region.** M. L. Mittal, G. H. Masapati (Indian Institute of Technology, Bombay, India), and V. K. Rohatgi (Bhabha Atomic Research Centre, Bombay, India). *International Journal of Energy Research*, vol. 3, Apr.-June 1979, p. 189-199. 8 refs. Research sponsored by the Council of Scientific and Industrial Research of India.

In this analysis, the velocity and the current distributions and the efficiency of the MHD generator in the inlet region of the duct are analyzed for the case when the conducting fluid enters the duct with a uniform velocity. It is found that the Hall and the ion-slip currents produce fluctuations in the current components. Transverse current, surprisingly, does not show any fluctuations for the parameters used in this analysis. The efficiency at any point in the developing flow region is more comparable with that in the fully developed region. The variation of axial current, transverse current and the efficiency for various parameters in the developing region are shown graphically. (Author)

A79-33836 **An electrochemically regenerative hydrogen-chlorine energy storage system.** D.-T. Chin, R. S. Yeo, J. McBreen, and S. Srinivasan. *Electrochemical Society, Journal*, vol. 126, May 1979, p. 713-720. 10 refs. Research sponsored by the U.S. Department of Energy.

A study has been made to characterize the operating conditions of an electrochemically regenerative hydrogen-chlorine energy storage system. A nonsteady-state mass and heat balance was used to determine the changes in the electrolyte concentration, temperature, cell voltage, and flow rate requirements during charge and discharge. The over-all electric-to-electric efficiency was calculated for various operating overvoltages. A simple thermal analysis is also presented for estimating temperature excursions and system performances.

(Author)

A79-33887 **Solar-radiation-excited CO₂-Br₂-He gas laser (O gazovom lazere na smesi CO₂-Br₂-He s solnechnym vozbuždeniem).** B. F. Gordiets, V. Ia. Panchenko (Akademiia Nauk SSSR, Fizicheskii Institut; Moskovskii Gosudarstvennyi Universitet, Moscow, USSR) and A. I. Gudzenko. (*Vsesoiuznaia Konferentsiia po Kogerentnoi i Nelineinnoi Optike*, 9th, Leningrad, USSR, June 13-16, 1978.) *Akademiia Nauk SSSR, Izvestiia, Seriya Fizicheskaiia*, vol. 43, Feb. 1979, p. 251-254. In Russian.

A solar-excited gas laser must satisfy the following requirements: (1) it must have a wide absorption band in the visible radiation range; and (2) it must be chemically stable. This paper presents calculations of a CO₂-Br₂-He laser with solar excitation. Solar radiation is absorbed in bromine during dissociation with a mean cross section of 3×10 to the -19th sq cm in the 1500-A spectral band. B.J.

A79-33919 **Efficient high-power high-energy neutral beams for the reference mirror reactor.** J. H. Fink, W. L. Barr, and G. W. Hamilton (California, University, Livermore, Calif.). *IEEE Transactions on Plasma Science*, vol. PS-7, Mar. 1979, p. 21-34. 19 refs. Contract No. W-7405-Eng-48.

The neutral beams for the reference mirror reactor are provided via four separate injectors using negative ions created by charge exchange in a cesium-vapor cell and neutralized by photodetachment. Each of the injectors delivers the equivalent of 1800 A of the desired mixture of 150-keV deuterium and tritium neutrals. Each injector consists of 23 ion sources with an associated cesium-vapor cell that converts 20 percent of the positive-ion output into negative ions D(-) and T(-). The negative ions are accelerated to the desired energy and subsequently pass through a photodetachment cell that is continuously illuminated by eight columns of iteratively pulsed lasers. As much as 95 percent of the negative ions are stripped, producing fast neutrals that pass between the cryopumps and shielding into the reactor. Innovations required to attain an overall efficiency of 81.2 percent include a continuously operating cathode for the ion source, a negative-ion beam line with cooled grids, a high-voltage accelerator with insulators shielded from the neutron and gamma flux, cryopanel that cycle between pumping and outgassing modes, and recovery of the waste thermal energy and charged beam energy. (Author)

A79-33925 **Selected areas of aerospace technical applications to civil engineering.** M. Biswas, D. B. Stafford, P. G. Teleki, and A. F. Flanders. (*American Society of Civil Engineers, Convention, Exposition, and Continuing Education Program, Chicago, Ill., Oct. 16-20, 1978.*) *ASCE, Transportation Engineering Journal*, vol. 105, May 1979, p. 223-231. 8 refs.

Aerial remote sensing techniques, technology for the generation, transmission and distribution of power, the matrix method of structural analysis, solar energy technology, and minicomputers for data collection systems are among applications of aerospace technology to civil engineering problems. Attention is given to infrared, radar, and multispectral imagery, cellular honeycomb composite materials, wind energy, advanced meteorological satellites, and graphic display consoles for environmental monitoring. J.M.B.

A79-33950 **Solar cooling in the tropics.** K. Gardner (Kenneth Gardner Associates, Ltd., Bridgetown, Barbados). *Sunworld*, vol. 3, no. 1, 1979, p. 2-7.

The design of solar cooling systems for the tropics in general and Barbados in particular is discussed. Active and passive cooling systems must be designed taking into account the local climate and latitude. Flat plate solar collectors, as opposed to tracking or concentrating collectors, are considered optimal for Barbados because of the high cloud cover present during most of the year. Absorption chillers suitable for use at the low temperatures provided by flat plate collectors include ammonia/water and lithium bromide/water systems, however neither type of chiller is currently available for solar cooling. The operation of a flat plate ammonia/water cooling system which uses chilled water instead of cool air to cool building space is illustrated. The initial cost of such a system is estimated to be three times that of a conventional system, with amortization in five to ten years. A.L.W.

A79-33951 **Designing thermally efficient buildings for the U.S. Midwest.** R. Wright (Hawkweed Group, Ltd., Chicago, Ill.). *Sunworld*, vol. 3, no. 1, 1979, p. 13-17.

The design of thermally efficient buildings utilizing natural energy sources and regionally available materials in the midwestern United States is discussed. Climatic factors necessitate space heating for most of the year in the region, while local topography, vegetation, orientation, soils and microclimate determine the types of heating and construction feasible. To reduce energy losses, buildings should be small, with a north-south to east-west ratio of 1 to 1.1 in cool zones and 1 to 1.6 in temperate zones. The building should also be properly insulated, with minimal internal energy

requirements. A solar heating system for a building should be integral with the structure; passive solar heating is achieved by the use of south windows and a thick concrete, masonry or water-containing wall to store the heat while active devices should be designed to use building structures already in use. A.L.W.

A79-33984 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1 - Solar energy 1. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 554 p. Price of eleven volumes, \$495.

Consideration is given to methods for measuring insolation, to flat plate collectors, and to concentrating collectors. Papers are presented on such particular topics as a solar radiation summary for Hawaii, the thermal performance of open-flow liquid solar collectors, a combination of solar direct electric conversion concentrators and heat collector system, and heliostat survivability and structural stability for wind loading. B.J.

A79-33985 Hawaii solar radiation summary. P. C. Ekern and T. Yoshihara (Hawaii, University, Honolulu, Hawaii). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 69-90. 15 refs.

Extensive historical records and newly measured sunlight transects were combined to form an annual sunlight map for Oahu. The average annual values for the coastal areas were high, just greater than 500 cal/sq cm/day, but the inland mountains had only 60% as much sunlight as the coastal zones. The winter radiation values in the depths of the south-facing leeward valleys were relatively high, much greater than those on shaded north-facing windward slopes. A 21-deg south-facing incline in midwinter gained 30% more sunlight than a horizontal slope. Diffuse radiation was a relatively high 40% of the global radiation. B.J.

A79-33986 Computer modelling of solar energy collection. I. H. Farag and M. Neville (New Hampshire, University, Durham, N.H.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 125-164.

Computer models are presented for analyzing solar incidence data for any given area over any length of time. The information obtained from the models can be used in the optimum design of the solar collectors, the solar storage, and the auxiliary heating unit. In the first phase of modeling the probability that the total incidence for an N-day period less than or equal to a specified fraction of the long-term daily average is studied. In the second phase a computer model which simulates a solar heating system is developed. From these two phases economic optimization of the design of a solar heating system can be carried out. B.J.

A79-33987 Accuracy of empirical relations for flat plate collector performance prediction. P. Caetano Lobo and P. I. F. Almeida (Paraiba, Universidade Federal, João Pessoa, Brazil). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 167-178. 5 refs. Research supported by the Financiadora de Estudos e Projetos.

Comparisons of measured and predicted flat plate collector efficiency are presented as functions of collector inlet temperature at given ambient air temperature and incident solar radiation intensity. Efficiency is also plotted against the ratio between collector inlet to air temperature difference and incident solar radiation intensity on a

horizontal surface. The results are used to verify the accuracy and limits to validity of the mathematical model used to describe collector performance and of the corresponding numerical solution. (Author)

A79-33988 New concept in solar thermal collectors. H. J. Spitzer (U.S. Army, Mobility Equipment Research and Development Command, Fort Belvoir, Va.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 179-190.

Models and prototypes of black liquid solar collectors were fabricated and tested. The concept of using a black fluid sheet simultaneously as absorber and heat transfer medium resulted in a considerable performance enhancement against conventional solar collectors. The weight of a total device structure also compares favorably with conventional collectors. The greatest potential of solar thermal collectors based on the concept of the black liquid, however, lies in the possible cost reduction per unit area of collector through the utilization of modern chemical engineering techniques in plastics materials. (Author)

A79-33989 Use of a honeycomb as solar radiation absorber and heat exchanger in an air-type solar collector. J. T. Pytlinski and R. E. Hightower (Kansas State University of Agriculture and Applied Science, Manhattan, Kan.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 191-198. 13 refs.

A honeycomb collector of an innovative design was built and tested. The main element of the collector is a honeycomb structure with a vertical wall thickness of 3.5 mills and 72 hexagonal holes per square inch, creating a heat transfer area of eighty-one which compares to a ratio of one for the flat-plate collector of the same external dimensions. The internal section of the collector is built in such a way so that the painted flat-black honeycomb serves as the solar radiation absorbing element and at the same time serves as the heat exchanger for the air passing through it. Due to the right direction of mechanical stresses, the honeycomb element is especially suitable for forming an integral part of a roof structure. The design of the collector, and its step-by-step construction, is presented in detail. The testing results of the collector show that output air temperature in the range of 200 F and efficiencies in the range of 80% could be obtained. (Author)

A79-33990 Stability of gas in the gap of inclined flat plate solar collectors - Effects of convective boundary condition and radiation. M. N. Ozisik (North Carolina State University, Raleigh, N.C.) and M. A. Hassab (Alexandria, University, Alexandria, Egypt). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 199-218. 25 refs.

Linear stability theory is used to investigate the thermal stability of an absorbing, emitting, scattering, nongray gas between two parallel plates heated from below and subjected to convective boundary condition at the upper surface. The physical situation considered is similar to that encountered in the gap of flat plate solar collectors with one glass cover on top. Results imply that the onset of convective motion in the gap of a flat plate collector can be significantly delayed if a suitable participating gas is contained in the gap. B.J.

A79-33991 Engineering influences on the thermal performance of open-flow liquid solar collectors. J. T. Beard, F. L. Huckstep, W. B. May, Jr., F. A. Iachetta, and L. A. Dirhan, Jr. (Virginia, University, Charlottesville, Va.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 219-231. 7 refs. Contract No. E(40-1)-4927.

The thermal performance characteristics of an open water-channel collector and of an open fluid-film (silicone oil) collector have been determined experimentally in an outdoor test facility. A numerical model has been developed to simulate the thermal performance of an open water-channel collector and to assist in the analysis of various modes of heat transfer. In addition to the customary linear relationship of thermal performance with $(T_{\text{sub}} - T_{\text{amb}})/I$, it was found that ambient temperature, flow rate and wind speed are important variables which influence the performance of such solar collectors. Improved glazing materials and double glazing were found to be design changes which significantly improve collector's performance. B.J.

A79-33992 * SOLARES - A new hope for solar energy. K. W. Billman, W. P. Gilbreath (NASA, Ames Research Center, Moffett Field, Calif.), and S. W. Bowen. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 233-255. 13 refs.

A system of orbiting reflectors, SOLARES, has been studied as a possible means of reducing the diurnal variation and enhancing the average intensity of sunlight with a space system of minimum mass and complexity. The key impact that such a system makes on the economic viability of solar farming and other solar applications is demonstrated. The system is compatible with incremental implementation and continual expansion to meet the world's power needs. Key technology, environmental, and economic issues and payoffs are identified. SOLARES appears to be economically superior to other advanced, and even competitive with conventional, energy systems and could be scaled to completely abate our fossil fuel usage for power generation. Development of the terrestrial solar conversion technique, optimized for this new artificial source of solar radiation, yet remains. (Author)

A79-33993 Further modeling of a solar collector based on linear clipped-V channels. K. C. Bordoloi, T. M. Murray, Jr., and F. A. Bynum (Louisville, University, Louisville, Ky.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.*

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 275-294. 15 refs.

This paper is concerned with the analysis of a clipped-V type of solar air-heating collector. A number of important parameters of the collector were computed in terms of the geometry as well as available insolation data. A workable procedure was developed so that we could obtain information on the behavior of collectors of similar design. The present work builds upon the ideas previously presented. (Author)

A79-33994 Design considerations for the energy receiver in a fixed mirror-distributed focus /FMDF/ solar energy system. L. D. Clements (Texas Tech University, Lubbock, Tex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.*

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 295-311. ERDA-supported research.

Consideration is given to the factors which influence the design of a receiver for the fixed mirror-distributed focus system. In this system the solar collector is a fixed spherical segment mirror which gives a line focus moving within the mirror region during the day. The receiver is a heat absorber, specially matched to the geometry of the focal region, which tracks the line focus. Particular attention is given to the problems of maximizing heat absorption efficiency while minimizing heat losses, choice of heat transfer medium, choice of flow geometry, and materials and manner of construction. B.J.

A79-33995 Test results of a moderately focusing flat-plate solar collector. H. S. Robertson (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.*

Volume 1. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 313-320.

Three versions of a moderately focusing flat-plate collector have been tested by several methods. They show higher efficiencies at high temperatures than comparable conventional flat-plate collectors, indicating the expected reduction in the heat transfer coefficient from hot fluid to surroundings, but the product which governs performance at low temperatures has not been as high as expected. Deterioration of the absorptance was found to be the most likely cause of the somewhat disappointing performance. (Author)

A79-33996 A combination solar direct electric conversion concentrator and heat collector system. J. G. Hirschberg (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 321-328.

A combination system is described which channels the more energetic part of the solar spectrum (toward the high frequency of yellow) into solar cell direct converters, while allowing the less energetic part to pass into a heat collector. In this way, waste is minimized, since only the more energetic photons can activate the direct converters, while the less energetic ones are utilized for heating. (Author)

A79-33997 A method for estimating hourly solar radiation for parabolic trough collectors. C. E. Bingham, D. M. Posner (Solar Energy Research Institute, Golden, Colo.), and J. O. Bradley (Desert Research Institute, Boulder City, Nev.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.*

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 329-340. 13 refs.

A79-33998 A novel design of evacuated-concentrating spherical collector. Y. Bayazitoglu and A. J. Chapman (Rice University, Houston, Tex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 353-375.

The proposed design is that of a spherical collector consisting of a fixed evacuated glass sphere internally reflecting at the lower hemisphere and with a fixed receiver-absorber plate contained inside it. Convection suppression is provided simply by evacuating the sphere; thus eliminating the convection loss. Concentration is achieved by reflecting the solar rays from the lower hemisphere onto the stationary, plane, receiver-absorber. The receiver-absorber plate is fixed in such an orientation that during the sun's virtual diurnal motion, the paraxial line of the hemispherical reflector always falls on a portion of it. Thus, the receiver-absorber can be made to receive the maximum amount of radiation for different daily positionings of the sun. A properly chosen receiver-absorber thickness also may make the collector less sensitive to seasonal variations and allows it to collect any imperfectly reflected energy. The complete concept is that of a collector consisting of an array of such glass spheres attached to a main conduit carrying the heat transfer fluid. (Author)

A79-33999 Solar energy conversion system - Four quadrant, two dimension linear solar concentrators. D. A. Kelly (Technidyne, Inc., Maspeth, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 377-392.

The four-quadrant two-dimensional linear solar concentrator consists of a conventional linear parabolic type concentrator unit, with the addition of top linear lenses to provide direct solar concentration on the top area of focal zone piping. With this geometrical arrangement all four quadrants of a focal zone pipe receive a uniform solar heating effect. The four-quadrant concentrators are advocated for dual solar conversion, both direct solar photovoltaic and indirect water-to-steam conversion to drive a simple steam turbine generator for electric power. This type of concentrator

provides concentration ratios up to 30:1, on a continuous water-steam focal piping circuit. B.J.

A79-34000 Optimization of a fixed solar thermal collector. J. D. Garrison (San Diego State University, San Diego, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 393-421. 10 refs.

A series of optimization steps have been carefully followed which lead almost uniquely to a particular collector design which is superior to other current fixed collector models. Optimization of the design of a fixed collector leads directly to an all-glass, evacuated collector tube with optimal (Winston) concentration. A front surface mirror on the inside walls of this collector tube concentrates sunlight on an internal glass absorbing tube coated with selective absorber. The collector tube dimensions are determined by minimizing the variable energy losses from an array of these collector tubes. The collector tilt, acceptance angle and selective absorber properties are adjusted to maximize solar radiation collection. B.J.

A79-34001 Heliostat survivability and structural stability for wind loading. F. M. Cutting (Honeywell, Inc., St. Petersburg, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 1.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 463-525. 6 refs.

A finite difference analysis was applied to a heliostat for the proposed ERDA 10-MW solar test facility near Barlow, California. The heliostat consists of four (10 sq m) mirror surfaces mounted in series on a box frame. Results show that the heliostat will certainly survive wind gusts with rms velocities of 38 m/sec in the stowed configuration and, considering the conservative nature of the assumed input to the analysis, it will probably survive a lot more. The reason for this apparent over-design from a stress level point of view is that the pointing accuracy requirement of plus or minus 2 mrad forced the design to be very rigid for operational performance and therefore left a large margin on the survivability requirement. B.J.

A79-34002 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2 - Solar energy 2. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 495 p. Price of eleven volumes, \$495.

Solar energy conversion and utilization are discussed with reference to storage and heat transfer techniques, heating and cooling, building applications, and industrial applications. Papers are presented on such particular topics as the transient analysis and optimization of an extended surface thermal storage unit which uses a phase change material, a liquid sorbent solar air conditioner, and the development of microprocessor-based control and instrumentation subsystems for solar energy applications. B.J.

A79-34003 Experimental investigation of a fused salt energy storage system. S. Banerjee, J. W. Hodgins, J. D. Kim, and J. Shewchun (McMaster University, Hamilton, Ontario, Canada). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 543-559. 5 refs.

The potential of dodecahydrate salt ($\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$) for energy storage in the heat-of-fusion mode was investigated. Over a typical salt working temperature range of 20 F, the salt can store about one million Btu in a practical heat exchanger in the form of a cube with 5.5 ft sides. Experiments have been performed to verify the heat storage capability of the salt and a demonstration module of 16,000 Btu capacity has been built. Results indicate that the system is practical. B.J.

A79-34004 Modular stackable hot water storage/heat exchanger system for solar installations. P. J. Melroy (Kirkwood Community College, Cedar Rapids, Iowa) and D. L. Spencer (Iowa, University, Iowa City, Iowa). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 561-570.

A79-34005 * Solar energy storage via liquid filled cans - Test data and analysis. H. Saha (Alabama A & M University, Huntsville, Ala.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 571-596. 15 refs. Grant No. NSG-8041.

This paper describes the design of a solar thermal storage test facility with water-filled metal cans as heat storage medium and also presents some preliminary tests results and analysis. This combination of solid and liquid mediums shows unique heat transfer and heat contents characteristics and will be well suited for use with solar air systems for space and hot water heating. The trends of the test results acquired thus far are representative of the test bed characteristics while operating in the various modes. (Author)

A79-34006 Transient analysis and optimization of an extended surface thermal storage unit which utilizes a phase change material. J. A. Edwards and K. J. Mody (North Carolina State University, Raleigh, N.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 597-617.

Thermal storage units which use the latent heat of paraffin compounds have the ability to store substantial quantities of energy in a temperature range which is of interest for solar and other low temperature storage applications (100-200 F). However, the time required for storing and discharging energy may be excessive as a result of the low thermal conductivity of the phase change material (PCM). One technique for overcoming this deficiency is to use extended surfaces to assist in transporting energy between the heat transfer fluid and the PCM. With this in mind, an analysis was made of a rectangular finned thermal storage unit with the purpose of evaluating the effects of varying fin thickness, fin height, fin spacing, fluid side flow parameters and fluid properties, the thermal properties of the PCM, and the thermal properties of the fin material on the storage capacity of the unit and its charging rate. B.J.

A79-34007 Experimental study of a heatpipe with an active porous medium. A. V. Spyridonos and N. R. C. Demokritos. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 619-627. 16 refs.

A heat pipe intended for solar energy applications is investigated. Gypsum is used as the active porous medium, since this material is reversibly decomposed in a certain temperature range. Properties of commercial-type gypsum are studied along with those of a heat pipe under steady state conditions for different inclinations toward the horizontal. Heat pipe efficiency is also studied under transient conditions. B.J.

A79-34008 * Analysis of dynamic effects in solar thermal energy conversion systems. C. L. Hamilton (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 629-642. 6 refs. Contract No. NAS7-100.

The paper examines a study the purpose of which is to assess the performance of solar thermal power systems insofar as it depends on the dynamic character of system components and the solar radiation which drives them. Using a dynamic model, the daily operation of

two conceptual solar conversion systems was simulated under varying operating strategies and several different time-dependent radiation intensity functions. These curves ranged from smoothly varying input of several magnitudes to input of constant total energy whose intensity oscillated with periods from 1/4 hour to 6 hours. B.J.

A79-34009 Domestic solar heating and cooling system for Kuwait and Saudi Arabia. V. M. Puri and M. A. S. Malik (Kuwait Institute for Scientific Research, Kuwait). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 663-682. 19 refs.

A79-34010 Design curves for a solar heated and cooled Kuwaiti home. V. M. Puri and M. A. S. Malik (Kuwait Institute for Scientific Research, Kuwait). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 683-707. 10 refs.

A79-34011 Design, performance, and economics of solar heating and cooling systems for single and multi-family residences. E. M. Wormser (Wormser Scientific Corp., Stamford, Conn.). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 709-730.

The paper will describe a solar heated single family residence of 1,400 square feet of heated space located near Rehoboth, Delaware. The residence has been operational throughout the winter of 1976/1977, and data on its technical and economic performance will be provided. A four unit multi-family townhouse unit located near Columbia, South Carolina will be described. This townhouse unit utilizes a centralized solar heating system which is highly cost effective. The unit has recently become operational. A solar heated, well water cooled, 20,000 square foot office building currently under construction in the Boston, Massachusetts area will be described. The cost and performance prediction of this system will be discussed, and the resulting economics will be outlined. (Author)

A79-34012 Refined model of solar space cooling system. R. L. Jenks, A. Kremheller, W. A. Rogers (University of Petroleum and Minerals, Dhahran, Saudi Arabia), and R. W. Jones (South Dakota, University, Vermillion, S. Dak.). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 731-747. 13 refs. Research supported by the University of Petroleum and Minerals.

Computer simulation was used to study the feasibility of a solar-cooled residential housing unit in the Eastern Province of Saudi Arabia. The study has progressed through a series of system models; emphasis here is placed on the development of the refined model which describes the operation of the WF 36 absorption chiller. It is noted that the results of the simulation are dominated by a single operating parameter of the WF 36 air conditioner: the maximum condensing water inlet temperature of 32.2 C. B.J.

A79-34013 An economic comparison between solar and conventional residential air conditioning in Miami, Florida. B. H. Rotolante (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 749-759. 6 refs.

A79-34014 Liquid sorbent solar air conditioner. H. I. Robison (South Carolina, University, Conway, S.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference*,

Miami Beach, Fla., December 5-7, 1977. Volume 2.

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 761-779. 50 refs.

A solar air conditioner with a maximum capacity of 5 tons has been designed to operate using triethylene glycol as a sorbent. This desiccant system utilizes a commercially available dehumidifier as the conditioner and an air flow across trickle collectors operating at 160 deg F as the solution concentrator. A unique feature is the use of a concentrated glycol solution operating at ambient temperature as a storage system. Although the use of well water to remove sensible heat yields a high COP, the device can also be operated at reduced efficiency with either a liquid-to-air heat exchanger or a cooling tower. (Author)

A79-34015 Sunbird I - Utah's first commercial solar home. G. W. Young (Ford, Bacon, and Davis, Salt Lake City, Utah). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 801-817.

The first commercial solar home in the state of Utah utilizes a unique architectural and solar system design. This design involves a complete custom design of all components, including a single unit 13.8 x 2.5 meter collector, and a sophisticated miniature control unit controlling ten dampers in the forced air system. Both heating and cooling are contemplated, with automatic switchover from one to another; no effort on the part of the occupants of the home is required beyond that necessary to set the designed thermostat temperatures. An additional feature is the ability of the heating system to operate in a backup mode with the control system shut down for testing or calibration. (Author)

A79-34016 Perspectives on solar electric power for small homes. J. R. White, J. F. Marshall, and R. D. Offenhauer (Mobil Research and Development Corp., Princeton, N.J.). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2.

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 819-833.

Photovoltaically-generated electricity has the potential for substantial contribution to the electrical needs of small homes in the U.S. at costs to the homeowner comparable to those from electric utilities. The dominant requirement is the development of solar voltaic panels costing of the order of \$200 to \$1200, in today's dollars, per peak kw generating capacity (i.e., surface of sufficient area to deliver one kw of electricity, when facing the sun on a clear day). The specific value depends on location and on costs of electricity delivered to homeowners via utility connection. Other requirements are: adequate unshaded roof area (facing south at the proper angle); some form of electrical storage; availability of an alternative electric power source. (Author)

A79-34017 The solar house. J. P. Michel (Ordre des Architectes, Neuilly-sur-Seine, Hauts-de-Seine, France). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 871-901.

Research and development relating to solar houses in France are discussed. Emphasis is placed on solar system design, house architecture, and economic aspects of solar heating. Existing solar houses in France are briefly surveyed. B.J.

A79-34018 Honeywell General Offices solar HVAC system. R. F. Block and D. E. Waters (Honeywell Energy Resources Center, Minneapolis, Minn.). In: *Alternative energy sources; Proceedings of the Miami International Conference*, Miami Beach, Fla., December 5-7, 1977. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 903-922.

Honeywell is presently in the construction phase for an advanced solar heating and cooling system for its new General Offices building (eight stories; 100,000 sq ft floor area) located in

Minneapolis, Minnesota. Over 20,000 square feet of trough type concentrating collectors will track the sun's elevation and supply solar energy at fluid temperatures in excess of 350 deg F. The solar system will provide 84% of the annual cooling energy, 53% of the annual heating energy, and 100% of the domestic hot water for the new office building. This paper describes the solar HVAC system in detail and discusses the significant performance analyses that have been developed during the system design phase. (Author)

A79-34019 * **Solar energy in California industry - Applications, characteristics and potential.** R. H. Barbieri and D. S. Pivrotto (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 931-942.

Results of a survey to determine the potential applicability of solar thermal energy to industrial processes in California are presented. It is found that if the heat for all industrial processes at temperatures below 212 F were supplied by solar energy, total state energy consumption could be reduced by 100 trillion Btus (2%), while the use of solar energy in processes between 212 and 350 F could displace 500 trillion Btus. The issues and problems with which solar energy must contend are illustrated by a description of fluid milk processing operations. Solar energy application is found to be technically feasible for processes with thermal energy requirements below 212 F, with design, and degree of technical, economic and management feasibility being site specific. It is recommended that the state provide support for federal and industrial research, development and demonstration programs in order to stimulate acceptance of solar process heat application by industry. A.L.W.

A79-34020 **The development and implementation of microprocessor based control and instrumentation subsystems for solar energy applications.** R. A. Payton, C. H. Spencer, and T. M. Murray, Jr. (Louisville, University, Louisville, Ky.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.*

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 943-950. 6 refs.

The administration building for the astronomical observatory of the University of Louisville in Oldham County, Kentucky functions as a solar energy proof-of-concept complex, involving the use of water collectors and the storage of heated water. There are multiple methods to control the components of the solar system in order to increase the system's overall efficiency. In addition, these components are under the direct control of a microcomputer system. This same microcomputer also collects instrumentation data for the total HVAC and solar systems for evaluating system operational characteristics and efficiencies. B.J.

A79-34021 **Solar energy conversion in marine biological systems.** A. Mitsui (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 2.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1013-1017.

The use of tropical marine microorganisms for fuel, food and fertilizer production is discussed, with emphasis on hydrogen photoproduction and nitrogen fixation. A blue-green algal strain has shown a hydrogen production rate of one cc per ml algal suspension per day in a nitrogen-free medium under an argon atmosphere; this high, stable production rate may make the algae an attractive source for hydrogen fuel. Many blue-green algae fix nitrogen and may serve as fertilizers. In addition, the soft cell walls of blue-green algae may make them suitable for processing as nutrients. Methane production aided by algal species also receives attention. J.M.B.

A79-34022 **Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3 - Solar Energy 3.** Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 475 p. Price of eleven volumes, \$495.

Consideration is given to solar-electric power generation techniques, to rural and agricultural applications of solar energy, and to solar energy economics and planning. Particular papers are presented on such topics as the construction of satellite solar power stations from nonterrestrial materials, solar powered irrigation systems, and the economic prospects of solar energy for industrial process heat. B.J.

A79-34023 **Solar thermal photovoltaic electric power generator.** W. E. Horne (ENERAD Corp., Bellevue, Wash.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1021-1047. 12 refs.

The paper considers the concept of a solar thermal photovoltaic generator which, theoretically, could reach efficiencies of the order of 70%. The concept consists of a solar concentrator which focuses solar energy onto an absorber heated to incandescent temperatures (2500-3000 K). The radiation emitted from the incandescent source has a peak energy spectrum that closely matches the band energy of silicon. The emitted long-wavelength radiation is directed onto photovoltaic cells which absorb that portion of the spectrum which has photon energies greater than or equal to the bandgap energy of silicon. The absorbed energy is then converted to electrical energy and heat in the cells. B.J.

A79-34024 **Photovoltaic power generation by use of compound parabolic concentrators.** A. J. Gorski, R. L. Cole, R. M. Craven, and W. R. McIntire (Argonne National Laboratory, Argonne, Ill.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1049-1090. 17 refs.

This paper presents the final results of an analytical and experimental study of the application of compound parabolic concentrators (CPCs) to solar photovoltaic conversion. The experimental phase consisted of the design, construction, and testing of two photovoltaic panels using CPC type concentrators. One panel used a conventional CPC trough design in which metallic reflection is used for the mirror surfaces. The second panel used the dielectric compound parabolic concentrator (DCPC) in which the concentrator is filled with a dielectric material that satisfies requirements for total internal reflection (TIR). Construction details and measured results for both of these panels are presented. The analytical phase consisted of a cost-effectiveness analysis of the concept of using CPC and DCPC elements for photovoltaic concentration. In addition, a two-dimensional (cone) version has been analyzed which has the potential of achieving \$0.15 to \$0.50 per peak watt. (Author)

A79-34025 **Photovoltaic conversion - Can its efficiency be improved through the application of color response data.** D. Ertel (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1105-1113.

The paper describes a technique for enhancing the electrical output of solar cells and thus increasing their cost effectiveness: FOCOPRAD (Filtering and fOCusing OPTimal RADIation). The technique simply involves the filtering out of ineffective radiation and the focusing of the rest, thus assuring the presence of a greater number of optimal photons at the p-n junction. B.J.

A79-34026 **Direct Solar Energy Conversion at Sea /DSECAS/ - Characteristics of a baseline concept.** W. J. D. Escher, R. W. Foster (Escher Technology Associates, St. Johns, Mich.), and T.

N. Veziroglu (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1115-1133. 12 refs.

The subject of the project is a direct solar energy conversion system sited in an equatorial ocean location. It is noted that this combination of a direct solar energy conversion system in this setting represents a heretofore unstudied family of systems. The possibility of using a number of alternative direct conversion methods such as photovoltaic, thermal heat engines, photochemical systems, etc. is noted and the advantages and disadvantages of ocean siting of such systems is discussed. The mariculture opportunity is particularly noted. A 'baseline' system comprised of high concentration ratio parabolic trough collectors, heat engines and electrolyzers/liquefiers of hydrogen and oxygen is presented to provide a basis for sizing and energy costs estimates. Comments on weather and sea motion as related to this class of system are presented. (Author)

A79-34027 Dual purpose solar-electric power plants. F. F. Hall (Stanford University, Stanford, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1135-1153.

The rationale for such plants is discussed. The elements of such plants are listed. Some elements are discussed in more detail. Dual purpose solar-electric power plants would generate both electrical power and hydrogen gas for use as a fuel. The oxygen gas liberated in the hydrogen producing electrolytic cells would also be saved and sold to owners of hydrogen age equipment. Both gases would be under 50 atma pressure or more. At these pressures the hydrogen and oxygen could be fired in compressorless gas-turbine drives of fuel cell-inverter units of high thermal efficiency. The economics of dual purpose solar-electric power plants are weighed against costs of nuclear fission reactor-electric plants including the added values of the heated steam exhausted from gas-turbines and fuel cells. A recommended energy policy for America, first published in 1975, is attached. (Author)

A79-34028 The construction of satellite solar power stations from nonterrestrial materials - Feasibility and economics. B. O'Leary (Princeton University, Princeton, N.J.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1155-1167. 23 refs.

Studies have indicated that satellite power stations manufactured from nonterrestrial material in space could alleviate the global energy crisis as early as the 1990s. Costs could be competitive with fossil fuel and nuclear power and an environmentally acceptable and inexhaustible supply of base-load electricity could be provided anywhere on earth. An Apollo-scale program, using the Shuttle for earth-to-orbit transportation, is all that would be required to begin a cost-effective program of satellite power station construction. B.J.

A79-34029 Complex solar-electrical plant of large capacity. A. Gokhman (Miami, University, Coral Gables, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1169-1187.

This paper is devoted to the serious problem of utilization of solar energy for electrical power generation. We propose an inflatable solar collector of concentrating type of parabolic shape with the ability to follow the sun. The system will have the ability to direct the concentrated beam towards the absorber by means of an auxiliary parabolic mirror which has the same focal point as the collector itself, an opening in the vertex of the collector and a flat deflecting mirror. These features permit the use of several collectors of this type for heating a common boiler in a steam turbine unit. The result is the production of electricity with units of reasonable level of

capacity. Also an energy storage system is described. This system forms with the solar-electrical plant an economically feasible producer of electrical energy (Solar Complex Electrical Plant).

(Author)

A79-34030 Solar powered irrigation systems. S. G. Varnado, L. L. Lukens, A. M. Perino, and S. G. Vandevender (Sandia Laboratories, Albuquerque, N. Mex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1207-1232. 5 refs. Research supported by the U.S. Department of Energy.

Analytical and experimental efforts aimed at assessing the technical and economic feasibility of solar-thermal irrigation systems are described. An experimental 25-hp system irrigating 60 acres of land in New Mexico is described along with the preliminary design for a 150 kWe system to be built in Arizona. Results of recent economic analyses are presented which indicate that stand-alone solar irrigation systems are not currently competitive with conventionally powered systems but that their competitive position will improve if year-round nonirrigation uses for the system can be found. B.J.

A79-34031 The crucial role of financial institutions in solar heating installations. J. R. Roney and J. F. Blair, Jr. (Franklin Institute Research Laboratories, Philadelphia, Pa.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1327-1341.

Financial institutions engaged in home mortgage financing or in construction loans have an overwhelming influence on the building market. The introduction of solar heating into the home owner market will depend greatly on the policies, attitudes, and practices of these financial institutions. A survey of over 100 of these institutions was conducted in order to sample these factors and to assess the corresponding effects on the solar heating market. Results confirmed previous indications that there were significant obstacles to overcome. A very positive method for using financial institutions to make life-cycle costing attainable for the home owner is suggested. B.J.

A79-34032 Solar water and space heating systems - Cost effective choices and economic impact of various incentive policies. H. L. Magnas, C. A. Allen, R. D. Stoll, and H. L. Walton (U.S. Department of Energy, Energy Information Administration, Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1343-1364.

This paper reports the results of analyses performed on solar water and space heating systems that are cost competitive with fossil fuel systems in various parts of the country. Two recent analyses which provide useful tools for gauging potential solar market penetration are discussed. The first is an economic analysis of the cost effectiveness of solar heating systems in 18 representative cities throughout the United States. The second involves a regionalized computer model that projects the numbers of buildings likely to install solar energy systems and the Btus saved through the year 1990 under a variety of scenarios. (Author)

A79-34033 Economic prospects for solar energy for industrial process heat. R. C. Spongberg (U.S. Department of Energy, Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1365-1381. 9 refs.

An overview is presented of recent studies undertaken to evaluate the potential of solar energy for industrial process heat applications. It is generally agreed that solar technology in prototype stages today will be able to provide sufficient thermal energy to accommodate a significant portion of the demands of industry by the next decade. There appears to be uncertainty about when the economic environment will be able to accommodate large scale adoption of solar technology. Economic barriers (high initial costs, artificially depressed fuel prices, and high retrofit costs) will have to be overcome along with institutional and environmental barriers. B.J.

A79-34034 Regional viability and solar commitment - An early adopter study. T. Sparrow (Houston, University, Houston, Tex.) and S. Warkov (Connecticut, University, Storrs, Conn.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1383-1397. Contract No. E(29-2)-3750.

Some results are presented of an exploratory study designed to collect data on the economic and social incentives involved in the decision to purchase solar energy systems. It is found that while most recent solar adopters still purchase solar systems for public-spirited motives (e.g., protect the environment), they are gradually being replaced by those who purchase solar solely for economic reasons. Those who purchased major solar systems (hot water plus heating and/or cooling) have encountered fewer problems with the equipment and are more satisfied with the dollar savings their systems generate than those who bought only hot water or other partial solar systems. B.J.

A79-34035 The role of solar energy in the solution of Turkey's energy predicament. A. Beba (Ege University, Bornova, Turkey). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1399-1412. 14 refs.

Turkey is taken as a model for developing countries with short supplies of such conventional energy resources as petroleum and coal. The past and present energy consumption of Turkey is examined and a mathematical analysis is developed for predicting the future energy needs of Turkey. Results indicate that Turkey has a very good solar potential and that the wise use of this resource can be a major breakthrough in the solution of its energy predicament. B.J.

A79-34036 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4 - Indirect solar energy. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 495 p. Price of eleven volumes, \$495.

Papers are presented on ocean thermal energy conversion (OTEC), wind turbines, and wind power generation. Particular consideration is given to such topics as OTEC power cycle design and OTEC commercialization, wind site selection for optimum wind power systems, and an energy analysis of a wind energy conversion system for fuel displacement. B.J.

A79-34037 Analysis of various OTEC missions. R. Cohen (U.S. Department of Energy, Washington, D.C.) and E. J. Tschupp (General Electrical Co., Washington, D.C.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1483-1504.

The market potential for OTEC has been identified as being electricity, and energy-intensive products (such as ammonia and aluminum). Market penetration scenarios are derived for electrical

utilities and energy-intensive industries in Southern and Southeastern United States, Puerto Rico/Virgin Islands and Hawaii. In addition, the potential of the production of hydrogen as an 'electrical bridge' to provide peak power at locations remote from OTEC sites is considered. A technological experience curve is derived for OTEC and applied to an OTEC systems model, to examine the potential market penetration scenarios. The institutional and incentive ramifications of OTEC market penetration are evaluated along with other requirements for OTEC development. The likely benefits of OTEC as a domestic energy source are estimated. Possible Federal incentives for the stimulation of OTEC commercialization are examined.

(Author)

A79-34038 An update of OTEC baseline design. P. A. Curto (Mitre Corp., METREK Div., McLean, Va.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1505-1519. 5 refs.

A review of ocean thermal energy conversion (OTEC) systems was conducted for the purpose of estimating OTEC costs and probable market penetration in U.S. energy markets. The Lockheed, TRW, and Applied Physics Laboratory concepts were examined. A generic OTEC grid-connected, floating, spar-buoy, fixed-position system concept was chosen as likely to be the most cost-effective of the configurations for which preliminary designs currently exist. An update of this OTEC generic design is presented along with cost estimates for each of the primary subsystems. B.J.

A79-34039 Major factors in OTEC heat exchanger design. D. Yung, J. J. Lorenz, and N. F. Sather (Argonne National Laboratory, Argonne, Ill.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1521-1532. 15 refs.

Major factors in OTEC heat exchanger design are discussed in light of previous and present work conducted by university and industry teams. The following design factors are considered: heat exchanger type (i.e., shell-and-tube and compact); modes of heat transfer and enhancement; materials and working fluid; biofouling and corrosion; and cleaning, repairing, and maintaining the units.

(Author)

A79-34040 Ocean thermal energy conversion /OTEC/ plant working fluid study. M. I. Nelson (Honeywell Corp., Hopkins, Minn.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1533-1556. 15 refs.

The present study examines a number of OTEC working fluids (ammonia, water, butane, propane, CO₂, ethane, hydrogen sulfide, and a number of Freons) with reference to efficiency, exchanger size, and ecology factors. A computer program was developed to model the OTEC-plant closed Rankine cycle and a study was made of the cycle efficiency and exchanger size with the candidate fluids. A second program was developed for modeling heat exchangers and aspects of the turbine; a final comprehensive study was made of total plant efficiency. B.J.

A79-34041 Major factors in OTEC power cycle design. J. M. Clinch (Argonne National Laboratory, Argonne, Ill.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1557-1569. 11 refs.

This paper provides an overview of those factors that are of importance in OTEC power cycle design. Both open and closed Rankine cycles are discussed in relation to their operation and reliability. Critical components in the closed Rankine ammonia vapor cycle are reviewed from the viewpoint of performance, cost, materials and maintenance. Estimates indicate that a trade-off exists between the parasitic pumping power requirements and heat ex-

changer performance. The need for operating the high capacity OTEC pumps and turbines at their maximum efficiency is also emphasized. (Author)

A79-34042 **Alternative forms of energy carriers from ocean thermal energy plants.** N. Biederman, A. Talib, B. Yudow, A. Konopka, and C. Blazek (Institute of Gas Technology, Chicago, Ill.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1571-1585. 11 refs. Research supported by the Institute of Gas Technology; NSF Grants No. C-1008; No. AER-75-00033; Contract No. E(49-18)-2426.

High temperature heat, carbonaceous fuels and electrochemical cells are assessed as alternatives to hydrogen, ammonia and under-water electric cables as carriers of energy generated at ocean thermal energy plants. Thermal energy storage media considered include sensible heat media, latent heat of fusion media and reversible chemical reactions. Carbonaceous fuels examined are methane, methanol and gasoline, synthesized from hydrogen produced by electrolysis on board the OTEC platform and carbon dioxide delivered from shore. Electrochemical systems investigated are a redox battery system and a lithium/water/air battery. It is concluded that the alternative energy carriers considered do not appear to offer any cost savings over hydrogen and ammonia as carriers of chemical energy, however the ability of methanol and gasoline to serve as transportation fuels may increase their desirability. The lithium battery is found to offer the greatest promise for delivering electricity to shore. A.L.W.

A79-34043 **The commercialization of OTEC - Problems and opportunities.** G. H. Lavi (Carnegie-Mellon University, Pittsburgh, Pa.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1587-1612. 8 refs.

A growth scenario is examined to determine the steps industry and government must take to achieve OTEC market penetration at the earliest possible date. Consideration is given to capital and resource requirements, and to growth rate of manufacturing capacity and product demand. It is suggested that it is questionable whether the private sector can undertake the commercialization of OTEC without government incentives and a well-established public policy for this new energy technology. It is shown that with the proper incentives OTEC can begin to penetrate the U.S. energy market by the year 2000. B.J.

A79-34044 **An axial-flow wind-turbine with delta-wing blades.** J. A. C. Kentfield and D. H. Norrie (Calgary, University, Calgary, Alberta, Canada). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1615-1645.

Results are reported of wind-tunnel tests of a small scale, dynamometer equipped, model wind-turbine representing what is believed to be a unique concept featuring delta-wing blades. It is shown that the inherent advantages of this blade form derive from both the low speed aerodynamic characteristics of delta wings and the ease with which such blades can be constructed. The best rotor efficiency attained with simple delta-wing blades was 48% (power coefficient = 0.286) at a velocity ratio of 1.4. With the addition of the delta-wing blades of plain flaps a Betz efficiency of 67% (power coefficient = 0.4) was achieved at a velocity ratio of 1.6. The rotor efficiencies and power coefficients incorporate corrections to compensate for the low Reynolds numbers of the model tests. In all tests maximum torque was achieved at zero rotor speed. The experimental results were also compared with a simple theoretical prediction of rotor performance. (Author)

A79-34045 **Windmills with increased power output due to tipvanes.** G. J. W. van Bussel (Delft, Technische Hogeschool, Delft, Netherlands). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1647-1661. 14 refs.

Betz's formula, yielding the maximum power output of windmills is only valid under the assumption that the windmill causes a steady axial force acting on the air in a direction opposite to the undisturbed stream velocity. When radial as well as axial forces are applied to the air, this theorem is no longer valid and larger power output may be obtained. This paper deals with a type of windturbine where relatively small vanes, attached to the tips of the turbine blades, deflect the air radially outwards. It describes the lay-out of the system, its potential performance and the research concerning the feasibility of tipvanes. (Author)

A79-34046 **Flap-cone control of windmill speed.** S. C. Tsai, C. Y. Liu, T. H. Tan, and S. L. Tay (University of Singapore, Singapore). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1681-1692.

The flap-cone method of controlling windmill speed is investigated. Combining the concept of flap control of air speed with the idea of a ducted windmill, the duct can be constructed as a flap-cone, which is a contraction cone made up of a number of movable flaps and used to regulate the rotational speed of the windmill. By opening and closing the flaps the speed of the air passing through the rotor of the windmill can be maintained at a certain desired constant value in spite of the variation of the on-coming air speed. A closed-loop hydraulic control system is designed to drive the cone-flaps automatically in maintaining the rotor speed constant. A model based on this concept was constructed and tested. Test results show that within the controllable range of the wind speed the performance of the control system is very satisfactory. (Author)

A79-34047 **Theoretical study of a hybrid wind turbine.** I. Paraschivoiu, E. Bilgen, and F. Da Matha Sant'Anna (Ecole Polytechnique, Montreal, Canada). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1693-1702. 7 refs.

In this paper, a theoretical study is presented on a hybrid wind turbine which consists of two vertical axis coaxial turbines, one of Savonius type and the other a screw type. The Savonius type turbine has n sub 1 heliocoidal blades and rotates in a uniform velocity field while the second, the screw type, converts the kinetic energy of the vortex flow generated in the center of the first turbine. Each system is separately treated from the aerodynamics point of view and the corresponding developed powers and efficiencies are calculated. Then the two types are combined together as one unit to give the final results for a hybrid turbine. It is shown that the efficiency of such a hybrid wind turbine can have higher efficiencies than those obtained from a simple system. (Author)

A79-34048 **Optimal location of windmills.** T. P. Torda. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1779-1785. 27 refs.

Technical and land use factors in the siting of electricity-generating windmills are considered. Methods for collecting wind data at a given location have traditionally included direct measurement, with the computation of the speed-up factor and the Frenkiel number to account for the influences of hills on the flow field. Attempts are being made to replace costly on-site measurements by wind tunnel modelling and numerical analysis of boundary layer flows. Laser velocimeters show promise as means of measuring velocity fields over full-scale terrain. Land use research is represented by reports and regulations issued by various government agencies. It is recommended that studies of the dependence of wind on the

interaction of meteorological conditions with local topography and the necessary formulation of land use plans and regulations be carried out. A.L.W.

A79-34049 Wind site selection for optimum wind power systems. M. C. Smith (Michigan State University, East Lansing, Mich.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1787-1808. 6 refs.

A method is given for selecting wind sites for optimum wind power systems. It is shown that in some instances the site selection is independent of the system to be used. In other instances the relative system costs of blades and electric generators will affect the site selection. Mean wind and wind distributions at sites are the significant parameters used with some discussion of other effects such as turbulence and wind profile. Two dimensionless parameters, a blade area parameter and a power parameter are developed in terms of the shaft capacity or rated wind speed and the wind speed distribution. These parameters suffice for the analysis if estimates of blade related and generator related costs can be made. (Author)

A79-34050 A review of wind-electric conversion technology. R. Ramakumar (Oklahoma State University, Stillwater, Okla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1811-1834. 28 refs. Research supported by the Oklahoma State University and U.S. Department of Energy.

This paper presents a review of the major generation schemes proposed for wind to electrical conversion and discusses their merits and demerits in the context of energy collection, cost, operation, control and utilization. The size of the system and the nature of the wind regime strongly influence the type of generation scheme that will lead to cost effectiveness. With medium (50 to 250 kW) and large (above 250 kW) systems, cost of the electrical generator is expected to be only a small fraction (about ten percent) of the overall cost. Therefore, a significant percentage increase in the generator system cost can be justified if it results in a decrease in the cost of other components and/or increase the energy collection efficiency, leading to a lower cost for wind generated electrical energy. (Author)

A79-34051 Wind energy assessment. D. M. Hardy (Solar Energy Research Institute, Golden, Colo.) and J. J. Walton (California, University, Livermore, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1835-1863. 17 refs. Contracts No. W-7405-eng-48; No. EG-77-C-01-4042.

Major aspects of wind energy assessment are discussed. Representative examples of modern wind turbine generators are briefly described in terms of size, power, general design, and operating characteristics. Spatial and temporal scales of wind variations and meteorological data requirements are discussed. Meteorological conditions in several coastal and mountainous areas with high wind energy densities are summarized. Methods used to map wind energy variations over the island of Oahu, Hawaii, are presented as an example of wind energy assessment in complex terrain. The study is presently documenting wind resources by means of coordinated field data collection and numerical modeling efforts. A numerical wind-field model is used to calculate three-dimensional velocities over the island. Data are collected from remote field measurement stations located to improve model input data and to provide local wind energy measurements. A statistical analysis of wind observations is used to determine predominant wind patterns. Field measurement and numerical model results obtained for Oahu, Hawaii, are given to illustrate how this general methodology might be applied to other mountainous or hilly regions. (Author)

A79-34052 Wind energy conversion systems /WECS/ for central station and dispersed power applications. T. R. Kornreich and D. M. Tompkins (JBF Scientific Corp., Arlington, Va.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1865-1886. 12 refs.

A79-34053 Clean energy from humid air. K. Oliver, W. N. Groves, C. L. Gruber, and A. Cheung (South Dakota School of Mines and Technology, Rapid City, S. Dak.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1887-1900. 5 refs.

The paper reviews the status of a computer simulation study the aim of which is to find a cost-effective process to convert the energy in humid air into mechanical work, which will be used to drive an electric generator. Parametric studies are presented for expansion-compression cycles: Under suitable conditions, including large amounts of cooling during compression, this cycle has an attractive network output. The most promising mechanization uses vortex flow to achieve the necessary expansion and subsequent compression with cooling. B.J.

A79-34054 An energy analysis of a wind energy conversion system for fuel displacement. W. D. Devine, Jr. (Oak Ridge Associated Universities, Inc., Institute for Energy Analysis, Oak Ridge, Tenn.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1901-1924. 12 refs.

Energy conversion machines which utilize renewable supplies of energy as fuel may deliver considerably more energy to ultimate users than is consumed during manufacture, deployment, and operation of the machine. An input/output approach is employed to estimate the energy embodied in a 1500 kW(e) horizontal-axis wind electric generating station used to displace fossil fuel in an electric utility system. Five ratios comparing delivered electrical energy to the energy requirement of the wind machine are displayed. The results indicate that the system considered could be a large net producer of energy and should displace a quantity of fossil energy equivalent to that embodied in the machine in considerably less than one year. (Author)

A79-34055 Aeroelastic pump. D. E. Wilson (South Carolina, University, Columbia, S.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 4.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 1925-1946. 28 refs.

The idea of using the galloping or flutter mode of a suspended cable as a simple inexpensive wind energy source has previously met with failure due to the difficulty inherent in extracting energy from the cable. However, this study has demonstrated at least in theory that when the cable is of a hollow configuration and filled with a fluid, it can be employed as a peristaltic pump. The flutter or galloping mode of the hollow suspended cable is employed as an oscillating wind energy extractor. This energy is then transmitted to the fluid inside the cable through the wall motion. The result is a peristaltic induced fluid transport in the direction of the traveling wave. The cable could then form one element of a water turbine system, or simply transport the fluid to a higher potential energy level for storage and later use. (Author)

A79-34057 Fusion energy - The iceberg beneath the tip. J. M. Williams, J. R. Airey, S. L. Bogart, and H. S. Cullingford (U.S. Department of Energy, Div. of Magnetic Fusion Energy and Laser Fusion, Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2389-2410. 7 refs.

The prospects for fusion energy are discussed. It is suggested that the uniqueness of the fusion process and its associated radiation and thermal environment may enable fusion to reach most of the projected energy demand sectors. Some applications, such as fusion-fission, are relatively near-term and do not require pure fusion reactor grade operation. The economic prospects for most fusion applications appear at least as attractive as for any other inexhaustible energy resource technology. B.J.

A79-34058 Report on a simple fusion reactor model that is already in operation. D. R. Wells, J. Davidson, P. Ziajka, L. Phadke, and J. Tunstall (Miami, University, Coral Gables, Fla.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2411-2430. 19 refs.

Experiments on fusion reactions produced by adiabatic compression of plasma vortex structures are discussed. The TRISOPS machine at the University of Miami has been modified by improving the preionization of the plasma and increasing the ring frequency of the conical theta pinch coils. The secondary magnetic compression field has been increased to 120,000 G at the conjugate points of the mirror. It has been possible, with this modified machine, TRISOPS IV, to obtain ion temperatures of over 5 keV with corresponding electron temperatures less than 300 eV. The ion temperatures were measured by two different methods. One method utilized the Doppler broadening of various spectral lines and the other employed neutron activation of various metal foils with both fast and thermal neutrons. The two methods gave essentially the same results. The corresponding electron density was 2×10 to the 17th per cu cm. This plasma was held in stable equilibrium for 8 microsec. A short discussion of the structure interactions during compression and alpha-particle heating after compression is given. (Author)

A79-34059 Fusion power demonstration study at ORNL. A. T. Mense and D. Steiner (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2431-2438. 5 refs. Research sponsored by the U.S. Department of Energy.

The aim of the ORNL Fusion Power Demonstration Study is to develop a plan for demonstrating, in this century, the commercial feasibility of fusion power based on the tokamak concept. Major results obtained so far include: (1) the outline of a three-phase plan for demonstrating the commercial feasibility of tokamak fusion power in this century, (2) a parametric analysis of tokamak costs which provides the economic basis for the demonstration plan, and (3) a critical evaluation of the technological directions, design approaches, and plasma characteristics which serve as the technical basis for the demonstration plan. B.J.

A79-34060 The ELMO Bumpy Torus - An alternative fusion reactor concept. N. A. Uckan (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2439-2453. 11 refs. Research sponsored by the U.S. Department of Energy.

The present status of ELMO Bumpy Torus (EBT) research at ORNL is described briefly in order to provide a basis for the reactor study. The EBT-I operation has experimentally demonstrated stable confinement in true steady-state operation and it can be projected that the system can scale to satisfy net fusion power conditions. Engineering design studies also demonstrated that with an inherently steady-state modular system the technological requirements are also relatively straightforward. B.J.

A79-34061 System studies for a tokamak fusion power plant. R. L. Reid and D. Steiner (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Alternative energy sources; Proceedings of the

Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2455-2476. 7 refs.

The impact of plasma operating characteristics, engineering options, and technology on the capital cost trends of tokamak power plants is described. Tokamak power systems are compared to other advanced energy systems and found to be commercially competitive. A three-phase strategy for demonstrating commercial feasibility of fusion power, based on a common-site multiple-unit concept, is presented. (Author)

A79-34062 Plasma-wall interaction and the tokamak fusion reactor. D. L. Styris, M. T. Thomas, D. R. Baer (Battelle Pacific Northwest Laboratories, Richland, Wash.), and J. Woo (MIT, Washington, D.C.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2477-2497. 26 refs. Contract No. FY-76-C-06-1830.

Impurities introduced into the plasma by interaction of the plasma with the containment vessel can appreciably alter (and may prevent attainment of) the plasma conditions necessary to achieve ignition in a tokamak fusion power reactor. This paper briefly outlines the nature and implications of the plasma-wall interaction problem as it affects ignition conditions. Areas of research and development needed to avoid or minimize this plasma impurity problem are then discussed. (Author)

A79-34063 Prospects of generating power with particle-beam-drive inertial confinement fusion. S. G. Varnado and J. L. Mitchiner (Sandia Laboratories, Albuquerque, N. Mex.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2499-2519. 26 refs. Research supported by the U.S. Department of Energy.

REB and ion beam accelerators with sufficient power to ignite a fusion reaction are under development. In the present paper, a description of current and planned accelerators is presented. In addition, a conceptual design for an electron-beam fusion-fission reactor is described and results of calculations of the busbar energy cost of a conceptual power plant using this reactor are presented. These costs are shown to be sensitive to pellet energy gain (thermonuclear energy out/beam energy absorbed), driver efficiency, and pellet cost. B.J.

A79-34064 A waste management strategy for nuclear fusion power systems from a regulatory perspective. R. A. Heckman (California, University, Livermore, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2521-2539. 18 refs. Contract No. W-7405-eng-48.

A waste management strategy for future nuclear fusion power systems is developed using existing regulatory methodology. The first step is the development of a reference fuel cycle. Next, the waste streams from such a facility are identified. Then a waste management system is defined to safely handle and dispose of these wastes. The future regulator must identify the decisions necessary to establish waste management performance criteria. The data base and methodologies necessary to make these decisions must then be developed. Safe management of nuclear fusion wastes is not only a technological challenge, but encompasses significant social, political, and ethical question as well. (Author)

A79-34065 Conceptual design study of a doublet fusion ignition test reactor. P. Sager (General Atomic Co., San Diego, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Pub-

lishing Corp., 1978, p. 2541-2561. Research supported by the U.S. Department of Energy.

The results of a conceptual design study of an ignition test reactor with niobium-titanium superconducting toroidal field coils are presented. This reactor, which is designed to reach ignition conditions and provide a plasma burn of 30 sec, has a major radius of 3.8 m, a plasma minor radius of 1.1 m, and a doublet plasma height-to-width ratio of 2.7. Such a reactor would be useful in demonstrating that ignition can be reached and in studying the burn dynamics of the plasma over a period of approximately 10 confinement times. It would also be useful in investigating plasma impurity effects and fueling techniques. B.J.

A79-34066 Production of synthetic fuels - An important civilian application of laser fusion. W. W. Meinke and H. J. Gombert (KMS Fusion, Inc., Ann Arbor, Mich.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 5. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2563-2574. 7 refs. Contract No. ES-77-C-02-4149.

It is suggested that direct utilization of fusion radiations to generate hydrogen/methane can provide an effective alternative to the generation of electricity. In laser fusion the simple geometric arrangement in which fusion occurs in a small pellet of about 1 mm in diameter will produce very large fluxes of 14-MeV neutrons emanating in all directions. These energetic neutrons can interact with chemical systems in a radiolysis process, combining radiolysis and thermally driven reactions. Hydrogen can then be incorporated into methane for pipeline use or into methanol for use in automobiles. B.J.

A79-34067 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6 - Geothermal energy and hydropower. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C. Hemisphere Publishing Corp., 1978. 406 p. Price of eleven volumes, \$495.

A computer optimization program for geothermal energy systems, existing geothermal space heating systems in Idaho and New Zealand, small-scale hydroelectric power plants in the northeastern U.S., and a salt gradient solar pond for heat extraction are discussed. Topics of the paper include the development of geothermal systems over an inferred upper-mantle swell, a thermogravimetric, binary-cycle loop for the exploitation of low-temperature geothermal sources, the use of geothermal resources for refrigeration, and large-span tension foils to extract energy from the sea. J.M.B.

A79-34068 Harnessing geothermal energy in Rotorua, New Zealand. R. J. Shannon (Ministry of Works and Development, Hamilton, New Zealand). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2577-2597. 6 refs.

Geothermal heat in Rotorua, New Zealand has been harnessed to provide a heat load of 1011 kW for buildings the floor area of which totals 9850 sq m. Kiln drying operations are also carried out with Rotorua geothermal resources. An economic analysis shows that capital costs of geothermal systems are higher than investments needed for coal-fired and oil-fired plants, though operating costs are much lower than for either of the fossil-fuel installations. J.M.B.

A79-34069 Geothermal systems in the Hauraki Rift zone /New Zealand/ - An example for geothermal systems over an inferred upper mantle swell. M. P. Hochstein (Auckland, University, Auckland, New Zealand). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2599-2610. 12 refs.

A79-34070 The Puchuldiza geothermal field. P. R. Trujillo (Corporación de Fomento de la Producción, Comité Geotérmico, Santiago, Chile). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2611-2621. 6 refs.

The Puchuldiza geothermal field is situated in the high Andes about 150 km northeast of Iquique, Chile. A minimum temperature of 200 to 205 C characterizes the geothermal fluid at Puchuldiza. Five drilling sites have been selected to tap the geothermal field. J.M.B.

A79-34071 Geothermal energy coupled with solar energy is the future energy in Saudi Arabia. A. A. M. Sayigh (Riyadh, University, Riyadh, Saudi Arabia). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2623-2640. 18 refs.

A79-34072 Manmade geothermal energy. T. K. Guha, K. E. Davis (Subsurface, Inc., Bellaire, Tex.), R. E. Collins, J. R. Fanchi, and A. C. Meyers, III (Houston, University, Houston, Tex.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2641-2654. 14 refs. Contract No. EG-77-C-04-3974.

The injection of hot fluids into deep permeable aquifers or impermeable caverns may provide efficient thermal storage systems. In this paper, thermal losses and pumping requirements for underground storage are studied with computer simulation techniques. For high-temperature, high pressure storage wells, thermal losses may be less than one percent. Such storage wells may be feasible in 80% of the continental U.S. The possibility of integrating base-line electric power systems and geothermal storage wells used in conjunction with large-scale solar collector/concentrator installations is also discussed. J.M.B.

A79-34073 Hot dry rock energy project. R. H. Hendron (California, University, Los Alamos, New Mex.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2655-2680. 29 refs. Contract No. W-7405-eng-36.

A proof-of-concept experimental project by the Los Alamos Scientific Laboratory endeavors to establish the feasibility of exploitation of the thermal energy contained in the earth crust where such energy and a transporting fluid have not been juxtaposed in nature. A region of high heat flow and apparently unfaulted basement rock formation was selected. Two boreholes, drilled to a total depth of about 3 km (10,000 ft) and penetrating about 2.5 km (7500 ft) into the Precambrian formation, to a rock temperature of 200 C, have been connected at depth by a hydraulically fractured zone to form the heat extraction surface. Energy was extracted at a rate of 3.2 MW(t) with water temperature of 132 C during a 96-h preliminary circulating test run performed late in September 1977. This paper traces the progress of the project, summarizes procedures and salient events, and references detailed reports and specialized topics. (Author)

A79-34074 Pilot facility for the experimental study of binary-cycle conversion systems - Thermogravimetric loop. G. Cefaratti (Ente Nazionale per l'Energia Elettrica, Milan, Italy), S. Arosio, G. Sotgia (Milano, Politecnico, Milan, Italy), P. Alia, and G. Morandi (Centro Informazioni Studi ed Esperienze, Milan, Italy). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2683-2707. 12 refs.

A thermogravimetric loop has been adopted for a pilot power plant suitable for the economical exploitation of low-temperature

geothermal sources. The pilot plant, capable of supplying 25 kW of power, is located at the Lardarello geothermal field in Italy. The thermogravimetric system is based on the generation of a difference in density between two branches of a vertical loop containing a fluid carrier (water) in the liquid phase. Injection of a vapor-phase organic fluid (Freon) at the base of one of the branches generates the density difference which drives flow in the loop. J.M.B.

A79-34075 The optimization of alternative energy cycles using program GEOTHM. M. A. Green, P. A. Doyle, H. S. Pines, W. L. Pope, and L. F. Silvester (California, University, Berkeley, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2709-2726. 14 refs.

A computer program has been developed to optimize thermodynamic cycles for cost, efficiency, or other user-specified parameters. The computer program has over 100 FORTRAN subroutines. Applications of the optimization capability to a geothermal power plant employing a binary or bi-fluid cycle, an ocean thermal power cycle, and a power cycle combining a gas turbine and a Rankine bottoming cycle are reported. Refrigeration cycles can also be treated by the optimization program. J.M.B.

A79-34076 Thermal fracturing patterns and effects of an imitation hot dry rock by impinging of water jets. H. Kiyohashi, M. Kyo, and W. Ishihama (Tohoku University, Sendai, Japan). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2727-2745. 18 refs.

Effects of rock temperature and water jet speed on the thermal fracturing of imitation hot dry rock specimens have been studied with reference to the establishment of drilling and fracturing methods for natural hot dry rocks. Specimens were made of castable fire-resistant material. Their compressive and tensile strengths are about 22 and 2.5 kg/sq cm, respectively, in the temperature range tested. Temperatures of the specimens were room temperature, 200, 400, 600, 800, 1000 and 1140 C. Water jet speeds used were 70, 84 and 98 m/s at the nozzle exit. The water was at room temperature. The distance between the nozzle exit and the test surface of a specimen was kept constant at 40 mm. Jet operation time was fixed at 10 sec. Experimental results indicated that fracturing patterns and effects varied with specimen temperature and jet speed. Phenomena observed in the experiments were explained by using the characteristic curve of the boiling heat transfer. (Author)

A79-34077 An exploration of the applicability field of geothermal water-fed heat pumps. P. De Marchi Desenzani (Pavia, Università, Pavia, Italy) and G. Giglioli (Milano, Politecnico, Milan, Italy). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2747-2765. 7 refs. Research supported by the Consiglio Nazionale delle Ricerche.

A79-34078 Geothermal community heating systems. J. F. Kunze, R. C. Stoker, and L. E. Donovan (EG & G Idaho, Inc.; Idaho National Engineering Laboratory, Idaho Falls, Idaho). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2767-2783.

The use of geothermal energy for central heating systems in Boise and Sugar City, Idaho is discussed. Analysis of the Boise geothermal energy system, in use since 1892, indicates that a redesign to increase the annual utilization factor would make the system more competitive with other sources of energy. At present the winter design temperature of the Boise system is -10 F, and the annual utilization factor is only 21%. It is also suggested that a

geothermal energy system should gross over a million dollars annually to be competitive with other sources of power. J.M.B.

A79-34079 Conserving electric power by geothermal refrigeration - Cooling and freezing. E. F. Wehlage (ISGE, Whittier, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2785-2800. 5 refs.

About 5% of the U.S. annual energy budget is employed for refrigeration. In this paper, the possibility of geothermal refrigeration at +5 C and as low as -50 C is examined. Unlike the production of electric power, refrigeration is an efficient use for geothermal resources. High-temperature heat pumps, mechanical-drive refrigeration units, lithium bromide and water absorption systems, water and ammonia absorption units, and steam jet vacuum cooling systems are among the possible means for utilizing geothermal resources for refrigeration. J.M.B.

A79-34080 Heat transfer consideration in utilizing solar and geothermal energy. J. W. Michel (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2801-2825. Research sponsored by the U.S. Department of Energy.

Although some forms of solar and geothermal energy will require the application of high temperature technology, most involve only low temperatures. This paper emphasizes the importance of efficient, low cost heat exchangers in the use of low temperature sources and in the waste heat rejection systems of power generation cycles. Heat transfer development work shows that for the working fluids which are attractive for use in these cycles the condensation heat transfer effectiveness can be improved by a factor of from three to seven by the use of fluted tubes and condensate drain-off skirts. Data are presented for the condensation of six fluorocarbons, isobutane, and ammonia on a variety of tube surfaces. These results are being applied to the design of a 40-tube heat exchanger to be tested in a geothermal energy test facility. (Author)

A79-34081 The economics of upgrading geothermal steam by adiabatic compression. A. Valfells (Iowa State University of Science and Technology, Ames, Iowa; University of Iceland, Reykjavik, Iceland). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2827-2839. Research supported by the Iowa State University of Science and Technology and Ministry of Education of Iceland.

Because of its relatively low temperature, geothermal heat is much better employed as a source of process heat in the chemical industry, than for electric power generation. Most chemical processes have been designed to use fossil fired steam conventionally produced at 250 C - 300 C, whereas geothermal steam is quite often only available at lower temperatures. This raises the question, whether low temperature geothermal steam, which is about the cheapest steam available, can be economically used in a turbine-compressor unit to compress some similar steam adiabatically to higher temperatures. The economics of such a facility, of 12 MW capacity, that is run by steam formed by double flashing at 175 C and 120 C and that compresses 190 C hot steam were investigated, and such compression was found to be economically feasible. (Author)

A79-34082 Low-head hydroelectric power - A realizable alternative. J. I. Mills and G. L. Smith (EG & G Idaho, Inc., Idaho Falls, Idaho). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2843-2856. 8 refs.

The utilization of hydraulic heads of less than 60 feet to generate hydroelectric power represents a substantial and potentially environmentally innocuous renewable energy source. Statistics in-

dicating that at least an additional 105 million kilowatts of hydroelectric capacity with a corresponding average annual generation of 387 billion kilowatt-hours may have the potential for future development. These data were compiled for sites with a potential greater than 5000 kilowatts, and the potential additional contribution from smaller sites, while not yet fully documented, appears to be substantial. These resources have not been fully developed because of economic and institutional factors together with an historic dependence upon large, centralized steam power plants at the expense of smaller, decentralized, appropriate energy technologies. Changing resource and energy use patterns, together with dramatic socio-economic developments, imply a future rapid expansion of low-head hydropower resource utilization. (Author)

A79-34083 **Small hydropower - Promise and reality in New York State and the northeast.** R. S. Brown and A. S. Goodman (New York, Polytechnic Institute, Brooklyn, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2857-2875. 16 refs.

An inventory of 5300 existing dams in nine northeastern states showed approximately 1600 low-head (10 to 45 ft) dams estimated to be capable of hydroelectric power outputs in the 50 to 5000 kw range. Dams located near highways and in the vicinity of energy demand centers are preferred for hydroelectric development. To avoid operational constraints, flood control and water supply dams are usually not included in the hydroelectric development program. J.M.B.

A79-34084 **Energy from sea and air by large-span tensioned foils.** D. Z. Bailey (Bailey Engineering, East Greenwich, R.I.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2877-2907. 6 refs.

Kinetic energy in ocean and tidal streams, and in atmospheric winds may be extracted in large quantities by stretching hydro (aero) foils horizontally over large distances across moving streams. These foils can be made to span very large distances by designing them to sustain large tensile loads and arranging them in 'catenary like' arcs such that the major forces are devoid of bending moments. Tensile loads are applied to the stream by placing massive concrete anchorages at opposing points across the stream. Thus the earth absorbs the complex compression forces presented by the energy flux. Supplementary structures stabilize the catenaries and extract the mechanical energy. For smaller systems of one to 10 Mw the axial thrust might be absorbed by one or more barges. George's Banks is a likely site for wind systems in the Northeast. Wind velocities and real estate values favor such a marine location where the array may stretch for miles. (Author)

A79-34085 **Heat extraction from a salt gradient solar pond.** F. Zangrando and H. C. Bryant (New Mexico, University, Albuquerque, N. Mex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 6.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2935-2967. 35 refs. Research supported by the New Mexico State Energy Resources Board; Contract No. EG-77-5-04-3977.

A salt gradient solar pond is an efficient, low cost solar energy collection and long range storage system for low temperature heat. A full-scale demonstration salt gradient solar pond in operation for over two years is described. Operational parameters, selection criteria for the materials to be used, cost, performance, as well as the physical behavior of doubly-diffusive systems exposed to the environment are considered. Although the current research is primarily geared to space heating (which varies seasonally) and industrial process heating (which poses a constant demand), crop-drying, water desalination, cooling and electricity production are possible applications of the solar pond. In the second year of operation the large storage layer

has reached a temperature of 93 C; this is a record high for sodium chloride ponds with storage. Heat has been successfully extracted from the 175 sq m pond on a daily basis since November 4, 1977.

(Author)

A79-34086 **Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7 - Hydrocarbon conversion technology.** Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 481 p. Price of eleven volumes, \$495.

Consideration is given to the technology of coal gasification, liquefaction, and combustion. Papers are presented on such particular topics as the Synthane and HYGAS gasification processes, the effect of operating variables on reactor performance in the Synthoil liquefaction process, and the status of fluidized-bed coal combustion. B.J.

A79-34087 **A numerical simulation model for entrained flow coal gasification. I - The hydrodynamical model.** T. R. Blake, D. H. Brownell, Jr., and G. P. Schneyer (Systems, Science and Software, La Jolla, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 2971-3000. 7 refs. Contract No. E(49-18)-1770.

The results of the initial development (i.e., two-phase, turbulent, nonreactive flow) of a numerical simulation model for entrained flow coal gasifiers/combustors is presented. Modeled turbulent mixture partial differential equations describing the transient conservation of gas mass, momentum, turbulent kinetic energy, and turbulent dissipation rate and solid mass, momentum and turbulent kinetic energy are presented along with the appropriate constitutive relations. The resulting equation set has been numerically integrated using a unique, mixed finite element-finite difference formulation which permits considerable geometrical flexibility in one, two, or three space dimensions. The capabilities of the hydrodynamical model are demonstrated in steady-state and transient, two-dimensional calculations of a two-phase swirling flow representation of the injection plane of a typical entrained flow reactor. (Author)

A79-34088 **Chemical solutions to problems encountered in the gasification of coal.** P. A. Kittle and R. P. Bennett (Apollo Chemical Corp., Whippany, N.J.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3001-3020.

Two main problems have been encountered in pilot plant and actual operating coal gasifiers. These are the production of carbon-containing char residues and difficulties encountered in the buildup and removal of slag on and from the gasifier vessel. These problems can be solved with chemical technology. The prime reason for slag buildup and removal problems is the production of coal ash with fusion point properties inconsistent with gasifier design operating conditions. Application of a slag modifier to produce an ash with the desired melting point range will greatly alleviate the slag-handling and maintenance problems experienced in many units. The production of carbon-containing residues represents a loss of usable product production. A combustion catalyst can be applied to reduce the amount of residual carbon, thereby improving coal conversion efficiency and, hence, plant output. (Author)

A79-34089 **The Synthane process - A technical and economic assessment.** A. J. Weiss and C. E. Lummus. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3021-3055. 10 refs.

The Synthane coal gasification process for the production of pipeline quality gas is evaluated. The evaluation is based on data obtained from the Synthane pilot plant at Bruceton, Pennsylvania during operations conducted in February and August, 1977. The operation was carried out with Montana Rosebud coal at a pressure of 600 psig and a bed temperature of 1500 F. The data were used as a basis for the conceptual design of a commercial coal gasification plant with a capacity of 250 x 10 to the 9th Btu/day of pipeline quality gas. B.J.

A79-34090 HYGAS - A process ready for commercial demonstration. B. S. Lee (Institute of Gas Technology, Chicago, Ill.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3057-3074. 12 refs.

In the HYGAS coal gasification pilot plant program, technical feasibility of operation has been demonstrated for all three major coal types in the U.S. Current tests involve caking bituminous coal of high sulfur content. A large amount of reaction kinetic data and integral gasification data from bench, process-development-unit, and pilot-plant scale operation is being integrated with the fluid mechanics of gas-solids contact to produce a comprehensive computer model for predicting gasifier performance. The validity of this model is illustrated by close check between actual and predicted gasification performance at different scales of operation. B.J.

A79-34091 Catalytic gasification of coals pretreated with liquid ammonia. Y. Tamai, H. Iwasaki, K. Fujinawa, H. Ishii, M. Matsuda, and Y. Nishiyama (Tohoku University, Sendai, Japan). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3075-3085. Research supported by the Ministry of Education.

A79-34092 Synthetic natural gas production from peat. D. V. Punwani, W. W. Bodle, P. B. Tarman (Institute of Gas Technology, Chicago, Ill.), and A. M. Rader (Minnesota Gas Co., Minneapolis, Minn.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3087-3112. 5 refs.

The paper touches upon several areas relating to peat including its composition, U.S. reserves, mining and dewatering, environmental effects, and gasification technology, with particular reference to the ERDA/Minnegasco peat gasification program. Gasification test results show that peat is not only more reactive than coal, but it also has a several-times-higher tendency to form methane. Proportions of gas and oil yields from a peat gasification process can be varied significantly by controlling hydrogasification temperature. B.J.

A79-34093 In situ gasification - Recovery of inaccessible coal reserves. P. R. Westmoreland, R. C. Forrester, III (Oak Ridge National Laboratory, Oak Ridge, Tenn.), and A. P. Sikri (U.S. Department of Energy, Div. of Oil, Gas, Shale and In Situ Technology, Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3113-3132. 11 refs.

About 90% of United States coal resources are estimated to be economically inaccessible by present surface and deep-mining techniques. Much of this resource - an estimated 1600 billion tonnes - could possibly be recovered by in situ coal gasification. In this technology, a gasification reaction front moving through the coal seam underground produces a combustible gas, which can be used to produce process heat, substitute natural gas (SNG), electricity, or can be converted to chemical feedstock. Preliminary calculations suggest that costs would be lower than those of surface gasification. In

addition, environmental effects could be greatly reduced and occupational safety and health improved. Based on the results of recent field tests, in situ gasification could make a significant contribution to future energy production. Ongoing development could produce a commercial process for low-Btu gas by 1985 and for a medium-Btu gasification process by 1987. (Author)

A79-34094 An evaluation of integrated coal gasification/water-splitting processes. S. E. Foh and J. S. Gahimer (Institute of Gas Technology, Chicago, Ill.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3133-3144. 5 refs.

Conceptual designs for combining an electrolytic water-splitting process with two coal gasification processes are presented, and relevant techno-economic parameters are calculated and compared. Analysis indicates that integrated coal gasification plus water electrolysis can produce a completely gaseous product at prices comparable to the cost of fuel products from the gasification process alone. The prices are close enough that several variable factors in the conceptual designs and marketing assumptions could determine the relative advantage of a given process for a specific application. (Author)

A79-34095 Coal gasification as applied to MHD power cycle. R. E. Gannon, F. A. Hals, and S. K. Ubhayakar (Avco Everett Research Laboratory, Inc., Everett, Mass.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3145-3161. 7 refs. Research supported by the Electric Power Research Institute, Baltimore Gas and Electric Co., Boston Edison Co., Consolidated Edison Company of New York, NEGEA Service Corp., New England Power Co., Northeast Utilities Service Co., Avco Corp., and OCR; Contract No. EF-77-C-01-2519.

The application of the magnetohydrodynamic (MHD) energy conversion process to electric utility power generation offers significant improvements in plant efficiency with a much better utilization of the fuel burned. Furthermore, the pollutants generated in combustion of coal, SO(x), NO(x) and particulate matter, can be removed in the process so that the combustion gases are thoroughly cleaned before they are emitted to the atmosphere. This permits all types of coal, including those with high sulfur and ash contents, to be directly utilized in the MHD power generation cycle without the necessity for separate flue gas clean-up. This paper is concerned with the use of coal in the MHD power generation process and discusses in particular the selective use of coal gasification in the cycle. (Author)

A79-34096 Transmission of energy by open-loop chemical energy pipeline. N. R. Baker, M. I. Scott, R. R. Tison, and T. P. Whaley (Institute of Gas Technology, Chicago, Ill.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977.* Volume 7.

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3163-3202. 29 refs. Research supported by the U.S. Department of Energy.

Three variations of the EVA/ADAM closed-loop chemical energy pipeline are developed and discussed. All three are based on the open-loop concept, that is, supplying hydrocarbons at the heat source and producing heat and substitute natural gas (SNG) at the distant methanator site. Both the hydrocarbon feedstocks and the interchangeability of the product SNG with typical natural gas types are discussed. An economic analysis of the first variant, or base case design, indicates a cost of 2.06 cents/kWhr for the heat product, and that this cost is not a strong function of distance between the heat source and end-use location. Conversion of existing natural gas transmission systems, underground storage of gases, and several of the potential institutional, safety, and environmental problems are also discussed. (Author)

A79-34097 A comparison of coal and biomass as feedstocks for synthetic fuel production. M. J. Antal (Princeton University, Princeton, N.J.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3203-3221. 17 refs. Research sponsored by the Council on Environmental Quality; U.S. Environmental Protection Agency Grant No. R-804836-01; Contract No. E(49-18)-2253.

The potential use of coal and biomass for the production of synthetic liquid and gaseous fuels has received widespread attention from differing groups during recent years. Conventional wisdom has maintained that the coal resource is much larger and more suitable for synfuel production than the biomass resource; however no comprehensive effort has been made to compare the strengths and weaknesses of the two fuels on a common basis. This paper constitutes a first step towards a sensible comparison of the two resources. Coal and biomass are first compared on the basis of their proximate and ultimate analysis. Following this, thermochemical calculations are used to predict the chemical products and gas calorific value of coal and biomass pyrolysis. Finally, studies of coal and biomass pyrolysis by thermogravimetry are used to compare the kinetic rates of gasification. These comparisons indicate biomass to be at least as well suited as coal for synthetic fuel production.

(Author)

A79-34098 Dynagas Process. M. S. Rakow and M. Calderon (Hydrocarbon Research, Inc., Lawrence Township, N.J.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3223-3234. Research supported by the Public Service Electric and Gas Co. and Elizabethtown Gas Co.

The Dynagas Process is a noncatalytic coal hydrogenation process uniquely designed to provide year-round energy peak shaving. The process has the flexibility to produce either a high Btu all-gas product or an all-oil product slate. Plant hydrogen and fuel requirements are internally generated from appropriate gas and liquid process streams. An initial plant design produced 100 MMSCFD of 1005 Btu/SCF (HHV) gas or about 17,500 BPD of oil from 5360 tons per day of dry coal. The gas product contains hydrogen and C1-C3 hydrocarbons. While satisfactory for local peak shaving, it is not interchangeable with high pressure pipeline natural gas. Removal of hydrogen via hydrogen purification yields SNG and provides the option of recovering a more highly valued LPG. The oil products are low in sulfur and other potential as chemical or refinery feedstocks in addition to clean fuel for electrical peaking systems.

(Author)

A79-34099 Effect of operating variables on reactor performance in the Synthoil coal conversion process. T. Derpich, S. H. Chiang (Pittsburgh, University, Pittsburgh, Pa.), and I. C. James, II (U.S. Geological Survey, Reston, Va.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3237-3254.

The reactor performance of the Synthoil coal liquefaction process has been analyzed from data on pilot-plant operations. The reactor configuration consists of concurrent upflow of hydrogen and coal-oil slurry through a packed bed of cobalt-molybdenum catalyst particles. Typical operating conditions for the reactor are pressures of 13.8-27.6 MPa and a temperature of 450 C. The principal conclusions are as follows: (1) the extent of coal liquefaction is closely related to coal composition, (2) coal-tar slurries show a complex kinetic behavior, and (3) the maximum operating temperature is limited by the production of refractory materials and coke.

B.J.

A79-34100 The H-Coal pilot plant - History, description, and present status. L. M. Abrams (Hydrocarbon Research, Inc., Miami, Fla.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7,

1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3255-3265.

A coal liquefaction process which utilizes an ebullating bed reactor to convert all types of coals to liquid fuels has been adopted for the design of a pilot plant capable of processing 600 tons per day. In one operating mode, the liquefaction process can yield about 3.7 barrels of liquid per ton of coal; approximately 20 to 25% of the liquid product is naphtha, which may be upgraded to high octane gasoline. A second operating mode yields a low-sulfur boiler fuel oil product and a smaller percentage of naphtha and distillate fuels.

J.M.B.

A79-34101 COIL process - First generation commercial coal liquefaction plant. G. R. DeVaux, E. S. Johanson, and M. C. Chervenak (Hydrocarbon Research, Inc., Lawrence Township, N.J.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3267-3283.

The paper summarizes laboratory results obtained on the COIL process which (similar to the H-Oil and H-Coal processes) hydrogenate coal and oil. The process has several advantages (including product compatibility, process synergy, process simplicity, flexibility in using crudes or coal, and high yield vs. capital investment) which may make it possible to commercialize the process prior to other coal liquefaction processes.

B.J.

A79-34102 Coal liquefaction - The H-Coal process. P. Wellman (Ashland Oil, Inc., Ashland, Ky.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3285-3305.

A report of progress on the construction of the H-Coal pilot plant at Catlettsburg, Kentucky, scheduled for completion in the summer of 1978, is given. Consideration is also given to an in-house economic study of a commercial-size H-Coal plant. The results of the study including capital cost, financial analysis, and some economic projections, are presented.

B.J.

A79-34103 Status and future promise of fluidized-bed coal combustion. A. A. Jonke (Argonne National Laboratory, Argonne, Ill.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3309-3319.

Fluidized-bed coal combustion technology is under development for applications to central station power generation and industrial process heat production. The primary incentive is the excellent opportunity that this technology offers for control of sulfur oxide and nitrogen oxide emissions and the potentially favorable economics compared with competing technologies. The strategy worked out by DOE is to have private industry participate with the federal government in the design, construction, and operation of a variety of industrial size and electric utility pilot-plant combustors.

B.J.

A79-34105 Residual shale oil as a boiler fuel. T. T. Fu (U.S. Navy, Civil Engineering Laboratory, Port Hueneme, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 7. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3397-3409.

A type of heavy shale oil was tested using two open air burner test facilities and two operational utility boilers. Air, steam, and rotary cup atomization burners were used during these tests. Results show that this shale oil may be handled and fired the same as conventional heavy fuel oils. Its flame was cleaner and brighter in appearance and emitted higher thermal radiation than those of conventional No. 2 and No. 5 fuel oils. After a total of 428 hours intermittent firing in a 20,000 lb/hr boiler, no abnormalities were

observed on the boiler interior surfaces and the specimens of refractories and boiler tube placed at various locations inside the boiler. The particulate emissions were low but the NO(x) emissions were approximately three times that of the local environmental standard of 0.53 gr/10 to the 6th cal. In summary, other than the unacceptably high NO(x) emissions, this shale oil may be regarded as a satisfactory boiler fuel. (Author)

remove unreacted SO₂, recovering HI(g) from the phase, and decomposing the dried gas into H₂ and I₂. B.J.

A79-34106 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8 - Hydrogen energy. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 516 p. Price of eleven volumes, \$495.

Consideration is given to hydrogen production, storage, and utilization. Papers are presented on such topics as the chemistry of water splitting, the utilization of wind and solar energy to produce hydrogen, the hydrogen storage potential of various materials (including metal hydrides and ferrotitanium alloys), and hydrogen energy-nuclear heat systems. B.J.

A79-34107 Production economics for hydrogen, ammonia, and methanol during the 1980-2000 period. H. G. Corneil, F. J. Heinzlmann, and E. W. S. Nicholson (Exxon Research and Engineering Co., Linden, N.J.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3439-3458. 6 refs.

A79-34108 Comparison of two hydrogen production methods for nuclear-hydrogen conversion. S. E. Ossami (University of Azarabadegan, Tabriz, Iran). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3459-3477. 10 refs.

Two techniques are compared: (1) transport of CH₄ and condensate in separate pipelines to the nuclear plant and transport of CO and 3H₂ for methanation; and (2) transport of CH₄ and CO₂ to the nuclear plant in one pipeline and transport of CO and H₂ for methanation. In order to eliminate the risk of deposition of soot in the latter system, a modified system using CH₄ + CO₂ + nH₂O is proposed. B.J.

A79-34109 Water splitting - The chemistry of the I₂-SO₂-H₂O reaction and the processing of H₂SO₄ and HI products. J. H. Norman, K. J. Mysels, D. R. O'Keefe, S. A. Stowell (General Atomic Co., San Diego, Calif.), and D. G. Williamson (California State Polytechnic University, San Luis Obispo, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3495-3526. 24 refs. Research sponsored by the American Gas Association, U.S. Department of Energy, and General Atomic Co.

The reaction between I₂-SO₂-H₂O can be made to produce two liquid phases as products. One phase is a concentrated H₂SO₄ solution while the other is a solution of HI in H₂O and I₂. Steps for purifying the H₂SO₄ product phase before cracking include converting contaminant HI into I₂, removing I₂, and distilling out H₂O to the H₂SO₄-H₂O azeotrope composition. Steps required in converting the HI product phase into H₂ include degassing the heavier phase to

A79-34110 Thermochemical water splitting process using iron-copper-chlorine cycle. A. Sasaki, M. Tamai, K. Masai, F. Sato, and M. Harada (Hiroshima Technical Institute, Hiroshima; Mitsubishi Heavy Industries, Ltd., Tokyo, Japan). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3527-3540.

An efficient five-reaction iron-copper-chlorine cycle is described for improved thermochemical water splitting. Two of the five reactions are liquid-phase reactions which result in a low-reaction temperature and a mitigation of corrosion problem. The thermal efficiency of the Fe-Cu-Cl cycle calculated as a parameter of feed ratio of steam to chlorine in the reverse Deacon reaction is plotted. The efficiency is nearly 30% when the steam-to-chlorine molar ratio is 2. S.D.

A79-34112 Hydrogen from the wind - A clean energy system. M. Dubey (Lockheed-California Co., Burbank, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3551-3562. 7 refs.

A practical system for generating hydrogen from wind energy is proposed and the costs of such a system are estimated. Electricity generated by one or more large wind turbines is used for the electrolysis of water and the operation of electrolyte pumps, compressors and hydrogen storage systems. Wind turbine investment costs are derived as a function of rotor diameter, which is determined by the annual energy requirements and the power rating and capacity factor of the turbine. Cost estimates for electrolyzers, gaseous, liquid and hydride forms of hydrogen storage, auxiliary power units and power recovery turbines are presented and used to determine hydrogen costs using various systems. Hydrogen produced in this manner may become competitive with hydrogen produced from natural gas as gas prices rise and may be used to fuel vehicles and manufacture ammonium nitrate fertilizer. A.L.W.

A79-34113 Hydrogen fuel production by wind energy conversion. E. Ben-Dov (Israel Electric Corp., Ltd., Haifa, Israel), Y. Naot, and P. S. Rudman (Technion - Israel Institute of Technology, Haifa, Israel). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3563-3576. 7 refs.

The economic feasibility of using wind energy conversion to produce hydrogen fuel by the electrolysis of water is considered. Wind energy production of hydrogen to replace gasoline can be achieved by feeding wind-generated electricity through a utility grid to an electrolysis facility or by means of an electrolysis unit at the wind turbine site and subsequent transmission of the hydrogen produced to points of use. On-site hydrogen production leads to a cost savings of 25% over that of utility-produced hydrogen, due to the use of a fixed pitch rotor in place of the variable pitch rotor necessary for stable frequency and voltage supply to a utility. It is concluded that hydrogen can be produced by on-site electrolysis at a cost less than the current price of gasoline in Europe at wind energy conversion sites with mean wind speeds exceeding only 4 m/sec. A.L.W.

A79-34114 State of development in the area of water electrolysis /near term/. P. W. T. Lu and S. Srinivasan (Brookhaven National Laboratory, Upton, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3577-3604. 36 refs. Research sponsored by the U.S. Department of Energy.

Efforts to improve water electrolysis technology are being made using three promising approaches: (1) development of solid polymer electrolyte (SPE) water electrolyzers, (2) increasing the operating temperature of alkaline water electrolyzers from 80 C to 120-150 C, and (3) investigation of advanced concepts. The R&D efforts on SPE water electrolyzers are aimed at (1) low cost current collectors, (2) high-activity electrocatalysts, (3) high temperature capability, (4) low cost SPE, and (5) design and construction of scaled-up cell stacks. Attempts are being made to find materials for cells and auxiliaries which are stable in an alkaline environment at elevated temperatures. Advanced concepts for electrolytic hydrogen production include (1) finding better reversible electrocatalysts, (2) use of anode depolarizers, (3) water vapor electrolysis in molten or solid electrolytes, (4) development of hydroxyl ion transporting membranes, (5) investigation of thermochemical-electrochemical hybrid cycles, and (6) photoelectrolysis of water. (Author)

A79-34115 A new electrolytic cell type for hydrogen production in hybrid cycles. G. H. Schütz and D. R. Lalonde (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro Comune di Ricerche, Ispra, Italy). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3605-3627. 9 refs.

The feasibility of using hybrid processes for hydrogen production was demonstrated experimentally with aqueous HBr in undivided cells. The electrolysis products could be separated by controlled convective diffusion between horizontally arranged electrodes. The same yields as with diaphragm cells were obtained: 95-100%. Technical application of this type of cell could lead to significantly lower capital costs than for present-day water electrolyzers. B.J.

A79-34116 Hydrogen production at reduced cost through electrolysis and buoyancy. J. Horvath (Butler University, Indianapolis, Ind.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3629-3636. 9 refs.

An apparatus for harnessing the energy contained in the buoyancy of hydrogen and oxygen bubbles produced by electrolysis at deeply submerged electrodes is described. In the device, hydrogen and oxygen electrolysis products are used separately to drive power belts connected to an electric generator. In this manner, gravitational potential energy in the form of water pressure is used as a supplementary energy source to increase the energy yield from electrolysis and reduce the cost of hydrogen production. The apparatus is considered capable of improving the production, conversion, storage, transport, distribution and pollution control aspects of energy provision by leading to the increased usage of hydrogen fuels. A.L.W.

A79-34117 Liquid hydrogen from solar energy now. H. C. Zachmann (Associated Enterprises, Ellicott City, Md.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3637-3668. 19 refs.

Cost-effective hydrogen production using solar energy is found to be feasible in areas of high insolation with sources of fresh or salt water. The system would consist of a modular solar converter with collector, free piston engine, and a condenser; a dc voltage is generated which is applied directly to electrochemical cells for the production of hydrogen. Operational factors are discussed and production costs are examined. B.J.

A79-34118 A self-consistent process of producing hydrogen from sea water. M. A. K. Lodhi (Texas Tech University, Lubbock, Tex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3669-3673.

The production of hydrogen from seawater and hydroelectric power from an artificially created head is proposed as an energy extraction scheme for the Gulf of Mexico. The head would be created in an open reservoir as a result of natural evaporation and removal of sea water for hydrogen production. The artificial head could yield about 5 times 10 to the 10th BTU per year, while energy from hydrogen burning would amount to about 10 to the 16th BTU per year. J.M.B.

A79-34119 Biocatalytic production of hydrogen by an in vitro system. D. O. Hall, K. K. Rao, S. G. Reeves (King's College, London, England), and I. N. Gogotov. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3675-3696. 23 refs. Research supported by the Science Research Council of England, European Economic Community, and NATO.

The various factors which control the light-dependent production of hydrogen from water in an in vitro system containing chloroplasts, ferredoxin and hydrogenase are studied. Using *Clostridium pasteurianum* hydrogenase and chloroplasts from a variety of plants H₂ evolution rates of 20 micromoles per h per mg of chlorophyll, are normally obtained; in some experiments the rates increased up to 40 micromoles of H₂ liberated per mg chlorophyll in one hr. In the absence of scavengers of oxygen the rates and duration of H₂ production are decreased - both the hydrogenase and chloroplasts are inactivated under these conditions. The rates of electron transport in the chloroplast-hydrogenase system as measured by H₂ evolution were less than those obtained with chloroplasts and Hill reagents; however, parallel experiments indicated that chloroplasts which were active in H₂ evolution after 2h illumination still retained a fraction of their original Hill activity. H₂ evolution from water, in this anaerobic system, was inhibited by methyl viologen, potassium ferricyanide, and phenazine methosulphate. (Author)

A79-34120 State-of-the-art summary of the technical problems involved in the storage of hydrogen via metal hydrides. G. Strickland (Brookhaven National Laboratory, Upton, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3699-3711. 30 refs. Research sponsored by the U.S. Department of Energy.

The storage of hydrogen fuel in metal hydrides is discussed, with emphasis placed on experience gained from TiFe-based hydrides. The production of hydride-quality TiFe alloys and their behavior during extended cycling are considered. Vessel strain resulting from volumetric changes undergone by hydrides during cycling is also analyzed. Safety factors, cost-effective heat exchangers for hydride storage systems, and methods of enhancing heat transfer in the hydride beds receive attention. In addition, the design of hydride storage systems for automobiles is mentioned. J.M.B.

A79-34121 A survey of the hydrogen storage properties of nickel-copper-mischmetal-calcium alloys. G. D. Sandrock (International Nickel Paul D. Merica Research Laboratory, Suffern, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3713-3738. 24 refs. Research supported by the International Nickel Co.

The AB5 intermetallic compound LaNi₅ has ideal room temperature hydriding properties for the reversible storage of hydrogen. However, it is too expensive. An attempt was made to lower the cost

of hydrogen storage in AB5 compounds by first substituting the low cost rare earth alloy mischmetal (M) for La, followed by further substitution of Ca for M and Cu for Ni. A survey of the hydriding properties of the quaternary intermetallic compound $\text{Ca}(x)\text{M}(1-x)\text{Ni}(5-y)\text{Cu}(y)$ is presented as a function of x and y . Properties surveyed include plateau pressure, H-storage capacity, density, raw materials cost per unit of storage capacity and crystallographic parameters. Both Ca- and Cu-substitution are effective in lowering the plateau pressure of MnNi_5 . Cu lowers capacity faster than it lowers alloy cost. Within the $\text{Ca}(x)\text{M}(1-x)\text{Ni}(5-y)\text{Cu}(y)$ system, a variety of properties are available at materials costs substantially lower than LaNi_5 . (Author)

A79-34123 The potential of zeolite molecular sieves as hydrogen storage media. D. Fraenkel, R. Lazar, and J. Shabtai (Weizmann Institute of Science, Rehovot, Israel). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3771-3802. 15 refs. Research sponsored by the Ministry of Commerce and Industry of Israel.

The feasibility of using zeolite molecular sieves as hydrogen storage media by means of intracrystalline encapsulation is studied. The storage (encapsulation) efficiency of various zeolitic systems was measured in terms of VH_2 , the maximal capacity for hydrogen under a defined set of conditions, and T-M, the temperature of maximal rate of hydrogen release in temperature-programmed desorption. In general, A-type zeolites show markedly higher VH_2 and T-M values than X- and Y-type zeolites, mordenite, chabazite-erionite, gismondite, and thomsonite. B.J.

A79-34124 Modification of hydriding properties of AB5 type hexagonal alloys through manganese substitution. C. E. Lundin and F. E. Lynch (Denver, University, Denver, Colo.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3803-3820. 6 refs.

The changes in hydriding properties resulting from substitution of Mn for Ni in rare earth-pentanic nickel alloys of the hexagonal, AB5 type were investigated for the series $\text{LaNi}(5-x)\text{Mn}(x)$ and $\text{MMn}(5-x)\text{Ni}(x)$. Isothermal desorption data at 25 C are reported for cored, as-cast alloy hydrides and for homogenized specimens. Enthalpies for the hydride reactions are deduced from van't Hoff plots, and absorption-desorption hysteresis is observed. Mn is shown to have a powerful stabilizing effect on the hydrides of rare earth-pentanic nickel based alloys as would be predicted from the hole size vs. stability criterion, since Mn is a larger atom than Ni and hence expands the crystal lattice. Unlike other substitute atoms, e.g., Cu, Mn has little effect on the saturated composition of the hydride. Heat treatment is suggested wherever truly 'flat' isotherm plateaus are required for the intended use of the hydride. (Author)

A79-34125 Hydrogen Homestead. R. E. Billings, R. L. Woolley, B. C. Campbell, J. H. Ruckman, and V. R. Anderson (Billings Energy Corp., Provo, Utah). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3823-3841.

The Hydrogen Homestead demonstrates the use of hydrogen in a family home as a replacement fuel for natural gas, propane, and gasoline. Gas appliances and vehicles operate on clean-burning hydrogen. Hydrogen is shown to be complementary to solar and electric energy systems used in the home and provides for energy storage by means of a large metal hydride vessel. The home serves as a test facility for new prototypes and the interconnection of various systems as well as a demonstration of the role hydrogen can take in future home design because of unique properties and storability. As such, the homestead serves as a forerunner of a planned thirty-home development, utilizing hydrogen. (Author)

A79-34126 The self-propelled hydrogen-powered refrigerator car. R. L. Whitelaw (Virginia Polytechnic Institute and State University, Blacksburg, Va.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3843-3853.

Rail freight cars refrigerated by liquid hydrogen and propelled by gas turbines fueled by the evaporating hydrogen gas are proposed. In this paper, the speed, insulation and car shape are optimized to provide for delivery of a given cargo of frozen food at the lowest possible cost per ton-mile. Both manned and unmanned versions of the self-propelled refrigerator car are considered. Costs are found to be between one and two cents per ton-mile for journeys of between 500 and 1500 miles and annual cargos of 100,000 to 10 million tons. J.M.B.

A79-34127 Hydrogen energy transport systems and nuclear heat - A promising way to conserve fossil energy resources. K. O. Laughon and J. H. Swisher (U.S. Department of Energy, Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3855-3876. 22 refs.

The paper reviews the nuclear chemical heat pipe concept as it might be used for both closed and open cycle applications based on $\text{CH}_4 + \text{H}_2\text{O}$ yields $3\text{H}_2 + \text{CO}$ reversible reactions. Consideration is also given to information on potential markets, projected economics, technical state-of-the-art problems to be solved, and DOE activities and plans related to the concept. B.J.

A79-34128 Optimum design of automotive vehicles employing alternate energy sources of low energy density - Impact on selection of an energy-carrier for future urban vehicle transportation systems. R. F. McAlevy, III (Stevens Institute of Technology, Hoboken, N.J.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3877-3888.

A recently-developed, simple, analytical methodology for modeling energy-storage automotive vehicles has been employed to investigate the appropriateness of candidate energy-storage techniques for proposed missions. A naturally-occurring parameter, the vehicle 'ultimate range' - which depends directly upon the gravimetric energy content of the energy-storage device and the power-train energy-efficiency - is used to characterize the candidate. It is shown that the optimally-designed-vehicle total mass (a measure of initial capital and energy investment) becomes very large and the vehicle energy utilization becomes very low, unless the ultimate range is significantly greater than the range required for the mission. A criterion for prudent design is suggested. And finally, an example calculation shows that electric vehicles employing advanced lead-acid batteries are unsuitable candidates for an urban mission of 50 km (or more), while H_2 -fueled vehicles employing metallic hydrides for on-board storage are quite suitable. (Author)

A79-34129 Hydrogen as a mid-term gaseous fuel supplement by blending with natural gas. G. F. Steinmetz (Baltimore Gas and Electric Co., Baltimore, Md.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8*. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3889-3909.

The feasibility of blending hydrogen into the present natural gas delivery system as an energy supplement was investigated for the mid-term (1985-2000). Successful development of advanced electrolyzer technology and the availability of low-cost off-peak electric generating capacity are basic to this concept. It was determined that a major federally funded research, development, and demonstration program aimed at proving the technical feasibility of this concept is not justified within the next five years. B.J.

A79-34130 Feasibility study of a regenerative solid polymer electrolyte fuel cell system using hydrogen/chlorine reactants for high efficiency energy storage. L. J. Nuttall, J. F. McElroy (General Electric Co., Wilmington, Mass.), S. Srinivasan (Brookhaven National Laboratory, Upton, N.Y.), and T. G. Hart (Epergy Development Associates, Madison Heights, Mich.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 8.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3919-3936. 7 refs.

A79-34131 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9 - Energy delivery, conservation, and environment. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 528 p. Price of eleven volumes, \$495.

This ninth volume is concerned with five problem areas: heat exchangers, storage and delivery, waste utilization, conservation, and environmental considerations. Topics of interest include electrical augmentation of spray evaporators, energy storage by a new flywheel concept, and energy conservation by waste heat utilization. Also discussed are conservation as an energy source, and the cost of sulfur removal from coal in electric power generation. S.D.

A79-34132 Direct contact heat exchange for latent heat-of-fusion energy storage systems. M. C. Nichols and R. M. Green (Sandia Laboratories, Livermore, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3939-3958. 9 refs.

A computational-experimental work is performed to assess the feasibility of the 'shot tower' latent heat of fusion energy storage concept. The shot tower system uses mutually immiscible heat-transfer-fluid/phase-change-material pairs of different density in such a way that both the heat transfer fluid and the phase change material move. It is shown that a shot-tower-type heat exchanger using water/paraffin and having a length of about 2 m and a diameter of about 25 cm can extract heat from a tank of molten paraffin at a rate sufficient to supply domestic hot water to about ten families. S.D.

A79-34133 Moving bed heat transfer for advanced power reactor applications. T. A. Thornton and D. C. Schludberg (Babcock and Wilcox Co., Lynchburg, Va.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 3959-3980. 9 refs.

The concept is presented of a moving bed of free-flowing solid granules or microspheres as a mechanism for heat capture, storage, and removal for advanced energy source power reactors. Thermal energy is transferred to and from the particle bed in a baffled, gravity-induced flow. The primary requirement for the moving bed particles is the maintenance of a completely free-flowing quality. Other requirements include an adequate heat transfer rate across the contact surface, minimization of particle attrition and fines generation, and a high bed heat capacity. Particle transport would be accomplished by mechanical or gas lift methods, depending upon the specific application. Particular applications of this heat transport mechanism are envisioned in the areas of controlled thermonuclear fusion, solar power generation, and LMFBR intermediate loop. Experimental work was accomplished which verified previous research indicating attainable heat transfer coefficients adequate for steam generator design purposes, particularly with a helium as interstitial gas. (Author)

A79-34137 Experimental study of thermal energy storage by use of reversible chemical reactions. I. Fujii and K. Tsuchiya (Meiji University, Kawasaki, Japan). In: *Alternative energy sources;*

Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4021-4035. 7 refs. Research supported by the Iwatani Naoji Foundation.

A thermal energy storage method based on reversible chemical reactions is described. The validity of the method is verified through basic experiments performed by using Ca(OH)_2 and Mg(OH)_2 as most suitable thermal storage materials. Persuasive evidence in favor of the usefulness of the method is presented. The method is attractive since it provides long-term storage and high energy density by proper selection of suitable-thermal-storage materials. S.D.

A79-34138 A thermoeconomic analysis of thermal energy storage. K. W. Li (North Dakota State University, Fargo, N. Dak.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4037-4055. 7 refs.

A simple though general analysis of thermal energy storage systems (TESSs) is presented from a thermoeconomic standpoint. The TESS can be as simple as a hot-water tank with its control valves, or as complicated as an underground compressed-air storage with an upper-level water reservoir to maintain its pressure; the storage medium may be either liquid or vapor and gas. The performance of a TESS is evaluated by the storage system efficiency, defined as the ratio of the thermodynamic availability flow at the exit during the discharge period to the availability flow at the entrance during the charge period. A sensitivity study that provides more information for TESS selection is included. An illustrative example is presented for the break-even cost differential calculations. S.D.

A79-34139 Energy storage by flywheels - A new flywheel concept. J. M. Vance, E. H. Holtzclaw, and R. T. Schneider (Florida, University, Gainesville, Fla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4057-4077. 8 refs.

A flexible, toroidal flywheel design is described. This flywheel is constructed from synthetic fibers which are not laminated. The flexible configuration is expected to minimize synchronous vibration, and experimental results verify that the flywheel tends to be self balancing. The main advantages are safety and economy. The flywheel will not explode or disintegrate without prior warning. It is also simple and inexpensive to manufacture. These factors seem to point toward flywheel use as a small scale device. As such, it could be used as a storage unit for individual households to yield energy when brown-out conditions occur. It might also be used as a source of emergency power. Due to inherent mechanical simplicity, the flywheel is a reliable storage system. (Author)

A79-34140 Advanced semiconductor technology for alternate energy sources - DC to AC inverters. C. T. Kleiner (Rockwell International Corp., Anaheim, Calif.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4079-4090. 8 refs.

Advanced semiconductors may be a key element in the integration of solar photovoltaic arrays into utility grids. Gallium arsenide photovoltaic semiconductor materials and multiple-dye planar solar concentrators should yield significantly less costly arrays. In addition, the solid-state d.c.-to-a.c. inverter could be a means for synchronizing solar energy output to existing utility grids. The advantages of a transformless inverter that would have a float capacity with respect to the power grid return are discussed. J.M.B.

A79-34141 Remote new energy sources utilization in on-site non-polluting power plant - Liquid air as energy carrier concept and final conversion plant design. P. De Marchi Desenzani (Pavia, Università, Pavia, Italy). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach,*

Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4091-4103.

The paper addresses the problem of finding a nonthermally polluting negentropy carrier. It is proposed that liquid air be produced at a floating plant linked with an OTEC power plant. The liquid air can then be transported in tankers, and ground pipelines provide further transportation to inland users. The liquid air is stored in underground reservoirs from which it is fed to the power plants. Some basic characteristics and the economics of the cold recovery cycle are studied.

P.T.H.

A79-34142 An evaluation of the potential for district heating in the United States. C. L. McDonald (Battelle Pacific Northwest Laboratories, Richland, Wash.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4107-4130. 15 refs.

Results from recent studies evaluating costs of district heating from geothermal resources and power plant waste heat are compared with results from other feasibility studies. Estimates of costs from these studies are comparable and indicate that district heating is competitive with other forms of heating. International experience in district heating is briefly surveyed, illustrating the variety of systems in use and proving the technical feasibility of district heating with hot water. The sensitivity of costs to major design parameters is examined to show the effects of possible improved system design and technical changes on reducing costs. Institutional barriers, which seem to be the major obstacles to building district heating systems, are discussed. Some special commitment to district heating is required to overcome the institutional barriers which are preventing the realization of the energy savings possible with district heating.

(Author)

A79-34143 A new and novel form of district heating using thermal effluents from electricity generating plants. G. T. McLoughlin and M. Reinbergs (Department of the Environment, Office of Energy Conservation, Ottawa, Canada). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4131-4174. 37 refs.

A79-34144 Waste heat as an alternative heat source. J. Karkheck and J. Powell (Brookhaven National Laboratory, Upton, N.Y.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4175-4191. 7 refs. Research sponsored by the U.S. Department of Energy.

Power plant reject heat would no longer be regarded as a waste product but rather as a valuable commodity if beneficial applications were to be developed. Large scale district heating systems could use this heat for residential and commercial space and water heating. For these applications the heat quality would have to be upgraded from a nominal 40 C to about 100 C. This temperature increase can be effected by operating power plant turbines at condenser conditions of one atmosphere pressure instead of the nominal value of .05 atmosphere. The principal effects of this alteration in operating conditions are a reduction in electric production efficiency from a normal 33% to about 25%, and production of very great amounts of saleable, useable, heat. The feasibility of this application is controlled by the cost of transporting the heat from the source to the consumer.

(Author)

A79-34145 Energy conservation by waste heat utilization. S. C. Lee (Missouri-Rolla, University, Rolla, Mo.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4193-4207. 10 refs.

Utilization of waste heat through the use of a bottoming cycle application has been investigated for a typical large nuclear power plant. The Ericsson cycle wheel, which can drop the cooling water temperature of 40 F while generating additional power of 5%, appears to be a feasible method of achieving energy conservation. The estimated performance of this device is based on available technology from an existing power plant. Further development may make the Ericsson cycle concept even more attractive from the standpoint of economy and environmental protection, because an improvement in component design and the optimization of systems performance are yet to be made.

(Author)

A79-34146 Multiple section Minto Wheel driven by heat recovery from flue, steam, and return pipes of household heating systems /plus solar heat/. D. A. Kelly (Technidyne, Inc., Maspeth, N.Y.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4209-4220.

The multiple section 'Minto Wheel' is proposed and advocated as an auxiliary power source for producing electrical power for secondary electrical heating and other home electrical needs. The heat required for driving the 'Wheel' will be recovered from home heating system flue, steam and return hot water pipes for conventional household gas or oil burner heating units. Although originally advocated as a single wheel unit this present descriptive data is based on combining individual units into a multiple assembly arrangement for greatly increased power output. The principle of operation of the Minto Wheel is based on alternately heating and cooling of a low boiling liquid such as freon or propane which correspondingly decreases and increases the weight of opposite sets of sealed containers. Opposite sets of sealed, air-evacuated bottles are connected by tubing so that as the liquid freon at the lowest point on the 'Wheel' is heated it becomes vaporized and a portion of it rises up through the tubing to the upper and empty bottle. As the lower bottles now contain vaporized (lighter) freon and the upper bottles liquified (heavier) freon, the wheel will turn due to the effect of gravity.

(Author)

A79-34147 Pyrolysis gas from solid waste will provide total power demand for a major wastewater reclamation plant. R. C. Aberley, R. B. Sieger, and B. D. Bracken (Brown and Caldwell, Walnut Creek, Calif.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4221-4243. 9 refs. Research supported by the U.S. Environmental Protection Agency.

The background and process description of a 40 million gallon per day wastewater reclamation plant is reviewed as a prelude to describing some specific results and applications of a full-scale test of an energy conversion system which pyrolyzes a mixture of wastewater solids and municipal solid waste in multiple-hearth furnaces. Details of furnace operation, resulting gas characteristics and afterburner operation are presented. Advantages of pyrolysis over incineration are explained. Planned modifications to existing furnaces at the plant and details of additional equipment to be added are defined. Finally, the solid waste energy conversion system integrated with the water reclamation plant is described with an explanation of back-up provisions and air emissions.

(Author)

A79-34148 ECO-FUEL II - A superior refuse derived fuel. K. M. Kucera and J. A. Capp (Combustion Equipment Associates, Inc., New York, N.Y.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4245-4254.

The ECO-FUEL II process has produced a superior refuse derived fuel which overcomes the problems of alternative shredded fuel processes in the field of resource recovery. ECO-FUEL II is low in sulfur and has 8,000 BTUs per pound, which is equivalent to western coal. The product's low-moisture content permits indefinite

storage, while the fuel's high bulk density - a necessity for economical storage, handling, and market distribution - has been achieved. ECO-FUEL II's fine particle size promotes complete combustion in existing utility or industrial combustion systems while in use alone, or in conjunction with oil, or coal. The ECO-FUEL process utilizes conventional hardware proven in other industries. Net energy yield of the process is about 83%. The system achieves an answer to pollution from solid waste disposal that is economically and ecologically superior to any alternative in most urban areas.

(Author)

A79-34149 Net energy from municipal solid waste. N. L. Treat (Oak Ridge Associated Universities, Oak Ridge, Tenn.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4255-4276. 26 refs.

A brief discussion of several technologies for producing energy from municipal solid waste reveals that the system that produces solid fuel and uses it as a supplemental fuel at an existing coal-burning steam plant is the most promising process. Because of the economics and efficiencies obtained with the solid fuel process, it is used as a surrogate system for analysis. The municipal solid waste system involves a number of major activities: collection, transportation, processing, combustion, and final waste disposal. A brief description of each of these activities is given for reference purposes. An illustrative diagram of the overall system is included. S.D.

A79-34150 Alternative energy sources and conservation technologies - Optimal systems. G. F. Kah (Donovan, Hamester, and Rattien, Inc., Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4293-4309. 15 refs.

In formulating an energy management strategy for specific residential systems, the designer is faced with a perplex set of options and opportunities, unique to the energy system and climate considered. The paper discusses design considerations as they apply to the task of space heating in residences. Attention is given to passive designs: conserving availability; achieving high load factors; diversifying loads, scale and sources; using computer technology for load management and system control; and investigating global and local optima. S.D.

A79-34151 Assessment of energy conservation by using alternate energy sources in Kansas. J. T. Pytlinski and N. D. Eckhoff (Kansas State University of Agriculture and Applied Science, Manhattan, Kan.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4311-4321. 5 refs.

The minimum potential energy savings in Kansas by using incident solar energy and wind energy are being assessed. Applications such as space heating and cooling, water heating, and agricultural uses of solar and wind energy for pumping irrigation water are taken into consideration to establish energy conservation data now and for 1980. The use of biomass, for the generation of electricity and for space heating, is also evaluated to determine its possible contribution to the Kansas energy supply for 1980. The implementation plan to attain the energy conservation objectives is presented. Solar legislation in Kansas and incentives introduced by the state to develop alternate energy sources are discussed. It is estimated that in 1980 solar, wind and biomass energy can replace fossil fuels in Kansas to yield an equivalent energy savings of 178.2×10 to the 9th Btu, which corresponds to the equivalent of 29,700 bbl of crude oil per year. (Author)

A79-34152 Extraction of sensible heat from waste water for domestic heating applications. K. S. Varde (Michigan University, Dearborn, Mich.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7,*

1977. Volume 9. Washington, D.C., Hemisphere Publishing Corp., 1978, p.4323-4332.

A79-34153 Seasonal heat pump performance for a typical northern United States environment. J. B. Briggs and C. J. Shaffer (EG & G Idaho, Inc., Idaho Falls, Idaho). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4333-4355.

An analysis of seasonal heat pump performance in a typical northern United States environment (approximately 8000 degree-days of heating) was performed for several typical commercially available air- and water-source heat pumps. Typical air-source and water-source heat pumps were selected from an Air-Conditioning and Refrigeration Institute publication, 'Directory of Certified Unitary Heat Pumps' (1976). Parametric seasonal performance analyses were performed for each heat pump. The results of these parametric studies showed that typical air-source heat pumps currently on the market will, when used in conjunction with electrical resistance auxiliary heating, save on the order of 45% of the energy required to heat a standard-sized home normally using electrical resistance heating alone. Typical water-source heat pumps operating from 60 F and 80 F water-source temperatures will save on the order of 64% and 67% respectively, of the heating energy over electrical resistance heating for a similar heating requirement. Pumping water from deep wells reduces these energy savings considerably. (Author)

A79-34154 A gas absorption cycle for electric power generation. T. L. Hartman, III, J. R. Williams (Georgia Institute of Technology, Atlanta, Ga.), and T. L. Hartman, Jr. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p.4357-4371. 15 refs.

This paper presents a new thermodynamic cycle which, while operating under the same pressure and temperature restrictions as conventional Rankine cycle, offers a significant increase in performance. The cycle is a gas absorption cycle using an exothermic chemical reaction to absorb the working fluid. Preliminary results based upon a first law analysis of the cycle indicate a higher efficiency than a conventional Rankine cycle, without a significant increase in capital investment. The net result of this would be a decrease both in the cost of electric power, and in the energy consumed per kilowatt. Further advantages of the proposed cycle lie in the fact that the heat rejection temperature can be relatively large as compared to that of the Rankine cycle. This has important applications in total energy systems, such as power generation-desalination, power generation-refrigeration, or power generation and air-conditioning schemes. A further benefit of this high heat rejection temperature is a decrease in electric power plant site dependency on the availability of cooling water, since water to air heat exchangers may be used for heat rejection. (Author)

A79-34155 Environmental assessment of residential energy supply systems that use fuel cells. R. V. Steele (SRI International, Menlo Park, Calif.), G. L. Johnson (U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Research Triangle Park, N.C.), and G. Ciprios (Exxon Research and Engineering Co., Linden, N.J.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4375-4394. 8 refs.

Results are presented of an environmental assessment of residential energy supply fuel-cell systems providing electricity for heating and cooling of residences. Five distinct concepts for supplying residential energy are considered: coal-fired power plant, oil-fired power plant, combined-cycle power plant, fuel-cell power plant, and small fuel-cell system including heat recovery. All systems use coal as the primary resource. The environmental impact of each system is examined, and the analysis determines the costs of supplying heating/cooling and the overall energy efficiency of the systems considered. S.D.

A79-34156 A coal gasification-gas cleaning pilot plant at North Carolina State University. J. K. Ferrell, R. M. Felder, R. W. Rousseau, and D. W. Alexander (North Carolina State University, Raleigh, N.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4395-4415.

A79-34157 The cost of sulfur removal from coal in electric power generation. P. P. De Rienzo, R. Destefanis, and C. M. Trapani, Jr. (Gibbs and Hill, Inc., New York, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 9.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4417-4449.

A79-34158 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10 - Energy economics and policy. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 627 p. Price of eleven volumes, \$495.

The papers in this volume study the economics, planning questions, and strategies and policy making related to the alternative energy sources. Topics discussed include a unified methodology for cost analysis of energy production, effect of oil price increases on competitiveness of nonconventional energy technologies, technical-economic modeling in energy planning, the potential of alternative energy sources in meeting Air Force requirements, application of computer animation to dynamic display in complex energy systems, a nuclear-solar energy strategy, renewable energy supplies for developing countries, and energy policy optimization by environmental systems analysis.

P.T.H.

A79-34159 A unified methodology for cost analysis of energy production. D. L. Phung (Oak Ridge Associated Universities, Inc., Institute for Energy Analysis, Oak Ridge, Tenn.) and H. H. Rohm (U.S. Department of Energy, Washington, D.C.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4453-4500.

A unified methodology and common framework are proposed for cost analysis of energy production in a regulated utility environment. The revenue requirement methodology is the basic methodology; cost components include capital, fuel, operation and maintenance, and miscellaneous. Three modes of computation are differentiated: the then-current dollar mode, the base-year dollar mode, and the perpetual constant-dollar mode. The common framework provides for a position on the issues of time convention, tax and depreciation, inflation and escalation, discount rate, levelization and financial equivalence, externalities, developed and new technologies, etc. It also provides for a common set of parameter values, a set of boundary descriptive formats for technology identification, and a common form for all algebraic equations in the three modes of cost computation. The methodology and framework should be amenable to a sensitivity study to test the variability of results with respect to important parameters.

P.T.H.

A79-34160 Comparative economics of alternative fuels for intermediate services, combined cycle power plant. Y. K. Ahn (Gilbert Associates, Inc., Reading, Pa.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4501-4530. 12 refs.

The paper gives the results of a study of the performance and economics of intermediate-services combined cycle power plants

using one of the following fluid fuels converted from coal: medium-Btu gas, light coal liquid, and fuel grade methanol. An intermediate-loaded 200 MW combined cycle plant was selected for the study. For the medium-Btu gas, the Lurgi fixed-bed gasifier was chosen for its high operating pressure, good turndown capability, and fairly high throughput. The H-coal process for light coal liquid production was selected, and a medium-pressure, single-stage, oxygen-blown entrained gasifier was considered for fuel-grade methanol production. The effects of coal constituents and coal feed procedures on the thermal efficiency of these conversion processes was estimated. Plant investment and operating costs were computed on the basis of estimates of fuel availability and costs, and it was found that both high-sulfur and low-sulfur coal-derived medium-Btu gas would be competitive with natural fuel oils by 1980-1982. P.T.H.

A79-34161 Estimating the commercial potential and energy benefits of ERDA electric energy research. W. R. Park (Mitre Corp., METREK Div., McLean, Va.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4531-4553.

This paper presents a methodology which was developed by the staff at The MITRE Corporation to assist ERDA in assessing their RD&D programs in peaking and intermediate load electricity generation. The assessment technique is based upon the assumption that government sponsored RD&D has merit if the products of the RD&D can economically compete for a share of the future energy market. When the products are competitive, merits resulting from the RD&D programs may be measured, such as potential dollars saved, fuel saved, petroleum saved, etc. After describing the methodology development, some results obtained using the methodology in support of the ERDA-MOPPS exercise and the assessment of an accelerated ERDA program are presented.

(Author)

A79-34162 The impact of oil price increases on the competitiveness of non-conventional energy technologies. P. J. Farrelly (Exxon Enterprises, Inc., New York, N.Y.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4555-4567.

New energy technologies generally make use of products and services from diverse sectors of the economy. General inflation laws affecting the prices of these products and services must have a pronounced effect on the cost of implementing these technologies. For this reason, in order to assess the impact of oil price increases on the competitiveness of nonconventional energy technologies, it is necessary to understand the impact of the latter on price levels throughout the economy. If this proves to be significant, the ultimate commercial viability of now uneconomic energy systems may be much farther in the future than is generally realized.

B.J.

A79-34163 Energy impact on economic activity and long-term trend forecast. N. Hokkyo (Hitachi, Ltd., Atomic Energy Research Laboratory, Kawasaki, Japan). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4569-4573. 9 refs.

A biological growth model is used to extract long-term growth indices of major industrialized countries from short-term transient patterns of change of real GNP growth rates; the method is applied to the oil crisis of 1973-1976. The concept of 'biological time' is introduced.

B.J.

A79-34164 Technical-economic modeling in energy planning. D. J. Behling, Jr., E. A. Cherniavsky, K. C. Hoffman (Brookhaven National Laboratory, Upton, N.Y.), and D. W. Jorgenson (Harvard University, Cambridge, Mass.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami*

Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4575-4602. 10 refs. ERDA-sponsored research.

A combined technological-economic model has been developed and applied to the assessment of alternative energy technologies and policies. The individual models that have been assembled are the Hudson-Jorgenson model of the economy and interindustry transactions, and the Brookhaven Energy System Optimization Model. Other data bases and fixed coefficient input/output models are employed as data sources and accounting frameworks to support this combined technological-economic model. The combined model has been used to develop long-range projections of energy-economic relationships and to perform cost/benefit analyses of the U.S. energy R&D programs. The models assist in the comprehensive analysis of the interrelationships between technological change, the overall economy, and the environment as new resources and options such as conservation are implemented. (Author)

A79-34165 Energy use and society in the 21st century. A. J. Appleby (CNRS, Laboratoire d'Electrolyse, Bellevue, Hauts-de-Seine, France). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4603-4635. 57 refs.

On the assumption that by the year 2000 coal will play the major role in the energy picture, the effect of future energy development costs on a growing-GNP economy are assessed. Major conclusions are as follows: (1) capital constraints in the steady-state nonfossil economy will not permit a primary energy use per constant dollar of GNP that is greater than about 40% of the current U.S. figure and at the same time allow normal business activity; penetration of new energy technology will not be able to keep up with GNP growth in the transition period, but it should be possible to attain the 40% figure over a 25-year penetration period; (2) a capital trap will not permit the simultaneous production of energy consuming devices and capital-intensive energy-production devices - this will demand a reorientation of industry, away from heavy industrial sectors and toward manufacture of energy-saving devices with emphasis on long-lasting materials; (3) private capital should be used to reduce the amount of corporate capital necessary for the penetration of the future energy system. P.T.H.

A79-34166 The inexhaustible energy resources study. B. Miller and R. Blieden (U.S. Department of Energy, Washington, D.C.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4639-4666.

This document presents the results of a study conducted by the former U.S. Energy Research and Development Administration to assess the nation's future requirement for energy resources that are either renewable or sufficiently extensive to be considered inexhaustible. The focus of the study was on the 1990 to 2030 time frame and on the longer term inexhaustible resource technologies including solar, geothermal (hot dry rock only), fusion and fission breeders. The study explicitly considered uncertainties about future economic growth, the domestic resource base, import availabilities, conservation potential, environmental regulatory and sociopolitical impacts, and costs and availability dates of new inexhaustible energy technologies. Specific numerical results obtained to date cannot be viewed as definitive. Future work is needed to refine and modify the specifics of the methodology and the detailed results. The study has thus far derived some generally valid results which can be used in the U.S. Department of Energy R & D budget planning process and in determining how the federal government should respond to future events affecting the long range supply and demand for energy. (Author)

A79-34167 Survey and appraisal of primary future energy sources. D. H. Root (U.S. Geological Survey, Reston, Va.). In:

Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4667-4695. 38 refs.

Some rough estimates of the potential size of the following domestic alternative energy sources are calculated: Group 1 - wind power, water power, low-temperature solar energy, solar power through photosynthesis, tidal power, geothermal energy, and nuclear fission without breeders; Group 2 - nuclear fission with breeders, solar electric generation, and coal. The major conclusion is that the energy sources of Group 1 could supply only about 50% of the 1973 U.S. consumption rate, so that without oil and gas, half the U.S. energy would have to come from Group 2 sources. P.T.H.

A79-34168 Toward a rational energy supply system - Economies and diseconomies of scale in an expensive energy future. H. D. Steingass and G. F. Kah (Donovan, Hamester and Rattien, Inc., Washington, D.C.). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4697-4708. 11 refs.

While the present electric energy supply and delivery systems emphasize the centralization of energy production to take advantage of certain economies of scale, the 'rational' outlook indicates that in an environment of ever-rising fuel costs, the inherent inefficiencies of fuel cycles of extraction, conversion, and distribution can in fact represent significant diseconomies of scale. They do not capture the total systemwide efficiencies possible with conventional and new sources which are more directly matched, in both quality and scale, to the energy end-uses which they serve. New energy sources will likely be used at a range of scales and at all points along the centralization/decentralization spectrum. B.J.

A79-34169 The potential of alternative energy sources in meeting Air Force requirements. R. R. Barthelemy and D. C. Hall (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4747-4757.

A study is reviewed which was conducted to determine both current and future USAF ground power requirements and the power generation technologies most suited to satisfy such requirements. The initial part consisted of quantifying Air Force electrical and thermal ground power requirements, with total base, remote site, individual building, and other energy requirements categorized into 13 electrical and 9 thermal levels. In the second part, all possible energy sources, including fossil, geothermal, and refuse, were surveyed in terms of their potential for Air Force use. The final part involved determining the best energy conversion systems for operation under military constraints and the necessary adaptation that would allow optimum use of the selected systems in a military environment. It was established that there are numerous Air Force uses for alternative energy sources. A.A.

A79-34170 Energy resources for tomorrow - The possible role of non-nuclear and non-fossil energy resources. M. Meliss (Kernforschungsanlage Jülich GmbH, Jülich, West Germany). In: Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4759-4777. Research supported by the Ministry of Research and Development.

The paper presents the results of a study of the theoretical, technical, and economic potential of self-renewing energy sources, such as solar energy, wind, the energy of the sea, geothermal energy, and hydro power, on the world scale and more particularly in the context of the F.R.G. Main conclusions are as follows: (1) geothermal - application will be restricted to areas with exceptionally

high temperature gradients; (2) solar cell power production - may provide high grade energy but will not be economical in near future; (3) wind energy - will probably remain unimportant for energy supply system as a whole, and large scale wind energy conversion will depend on the solution of the energy storage problem; (4) heat pump systems - can lead to significant fuel savings, with disadvantage of need for additional high-grade energy; and (5) solar thermal collectors - application in the F.R.G. will be restricted to low temperature heat supply. P.T.H.

A79-34171 **Energy utilization in industry - The case of Israel.** T. Sonnino (Israel Atomic Energy Commission, Tel Aviv, Israel). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4779-4797. 6 refs.

The use of electricity in Israeli industry is analyzed. The development of industry in the years 1968-1975 is first analyzed with respect to total revenue, manpower and electricity utilization. The revenue per employed person and per kWh are calculated for 18 major industrial branches. It is found that in 1975 there was a variation of 40 times in kWh used and of less than 4 in employed persons, per unit revenue. When the added values in the different industrial branches are used in the calculations, the variations are reduced to 16 and 4.4. From 1968-1975 there was an average 5.2% yearly increase in productivity and practically no increase in the amount of electricity used per unit revenue. The relative values for Israeli agriculture and exports are also reported. (Author)

A79-34172 **Application of computer animation for dynamic display in complex energy systems.** R. B. Jones (Sandia Laboratories, Albuquerque, N. Mex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4799-4817. 7 refs. Contract No. AT(29-1)-789.

The potential impact of visual display techniques for improvement of human performance in complex energy systems is discussed. The logical decomposition of human stimuli/response is also discussed in the context of information display. An example of pictorial display is given. Computer generated films of abstract phenomena are shown to have a potential impact in training of complex energy system operators. One such film is discussed. The results of a questionnaire given to an audience is assessed with respect to retention and comprehension of the film's contents. (Author)

A79-34173 **Strategies for alternative energy sources.** G. C. Ferrell (International Institute for Applied Systems Analysis, Laxenburg, Austria). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4829-4866. 18 refs.

Strategies for alternative energy sources are developed out of an understanding of the historical evolution and possible future options for energy consumption. Work is presented that attempts to develop a fundamental and intuitive understanding of energy substitution and utilization patterns for a complex energy economy. A simple market penetration model is used to characterize the historical evolution and to assess national forecasts for energy consumption in the United States. Historic and nonhistoric trends are analyzed with respect to a number of factors including the domestic availability of oil and gas, economic parameters, environmental impacts, and government policy. In addition, a brief description is included of the programs and organization of the International Institute for Applied Systems Analysis. (Author)

A79-34174 **A nuclear-solar energy strategy.** P. L. Hofmann (Battelle Memorial Institute, Columbus, Ohio). In: *Alternative*

energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.

Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4867-4891. 36 refs.

One group of energy strategists tends to emphasize reliance on a single, specific energy source, while other analysts stress the diversity of our present energy supplies and recommend an even greater diversity in the future. A third view is examined which opts for the adoption of complementary energy systems that not only provide the sought for diversity, but also tend to be particularly well matched to each other. The nuclear and solar energy options are seen to be such intrinsically complementary energy sources. Both nuclear and solar technologies would be fully exploited but their implementation would be confined to those sectors of the energy economy for which they are best suited. The rationale for this proposed nuclear-solar energy strategy is described and some future scenarios are briefly sketched. (Author)

A79-34175 **Coupled systems and energy policy - Closing the supply/demand gap: Are there many roads not taken.** A. I. Berman (Danmarks Tekniske Højskole, Lyngby, Denmark). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4893-4902.

To simplify fuel transportation patterns and to avoid inefficient local development of energy systems, a synergistic approach involving international or interregional cooperation is suggested. For example, in the spring Norway and Sweden sell excess hydropower to Denmark, which has little hydropower of its own. In the autumn dry season, the pattern reverses as Denmark sells electricity from coal-fired steam plants to Norway and Sweden. A synergistic solution to fuel transportation is an agreement between Germany, the Soviet Union and Iran. Iran supplies natural gas to Germany. But instead of transporting the fuel the entire distance between the two nations, Iran supplies the specified amount to the Soviet Union, which in turn supplies an equivalent amount from its own supply to Germany. J.M.B.

A79-34176 **Economic, political and psychosocial barriers to a change-over to renewable energy resources.** J. O. Bockris. In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4903-4917. 15 refs.

A literature review suggests that the present energy systems of Western industrialized nations can last for about 20 more years. Conversion to new energy systems within 30 years would involve new capital investment at the rate of hundreds of billions of 1977 dollars per year. An inflation rate of 14%, or a substantial diversion of military expenditures are the alternative routes for such an energy conversion. In addition, public attitudes toward economic expansion need to be changed if conversion to new energy sources is to be accomplished. J.M.B.

A79-34177 **Introducing new technologies for alternative energy sources - The economic, social, and environmental considerations for developing countries.** E. H. Wright (University of Sierra Leone, Freetown, Sierra Leone). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4919-4926.

The introduction of solar, ocean-thermal, nuclear, coal-conversion, geothermal and wind energy systems into underdeveloped nations is discussed. Underdeveloped countries may encounter difficulties in exploiting such alternative energy sources if technological expertise and hardware must be imported from more advanced nations. The need to take into account social resistance to new technologies, and the problems of pollution associated with some of the alternative energy sources are also considered. J.M.B.

A79-34178 Renewable energy supplies for developing countries. J. W. Twidell (Strathclyde, University, Glasgow, Scotland). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4927-4953. 27 refs.

A basic theory of renewable energy supplies is presented and a strategy for the use of renewable energy sources is outlined. Several types of energy flows are schematically diagrammed: (1) natural and steady flow of renewable energy through the biosphere independent of human use, (2) flow of energy use in food for humans, (3) flow of energy from renewable sources using technological processes, and (4) flow of energy from nonrenewable sources. A simple model of the efficiency of energy use is proposed which shows that the per capita useful energy flow is increased if efficiency is increased, if input energy is increased, and if population is decreased without decrease in input energy. Patterns of energy use in developing countries are noted, and options in renewable energy supplies are briefly considered. As to a future energy strategy, it is emphasized that priority must be given to collecting and analyzing the environmental data that will be necessary for interfacing renewable energy devices.

P.T.H.

A79-34179 Function of economics in energy policy. L. W. Zelby (Oklahoma, University, Norman, Okla.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4955-4962. 24 refs.

In response to the current 'energy crisis', the author proposes that a move away from an energy intensive economy to a labor-intensive one be made. Conversion to more labor-intensive agriculture would increase the ratio of output energy to input energy and lead to a greater number of jobs. Use of biomass for fuel production such as methane, methanol, and ethanol would further increase agricultural production and demand for labor.

P.T.H.

A79-34180 Energy policy optimization by environmental systems analysis. L. V. Stover (NUS Corp., Rockville, Md.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4963-4987.

Envirodynamics is a method for developing solutions to policy development problems using a systematic, interdisciplinary approach. One of the main steps is the development of a matrix of energy policy alternatives and of environmental profile indicators as performance criteria to evaluate potential impacts. The method was used to assess the environmental impacts of a series of five-year development plans on the city, urban area, and region of Esfahan, Iran. An alternative impact analysis matrix was used to display the interaction of alternatives, involving expansion of steel production, limiting of heavy industry and expanding research and educational activities, transferring the capital from Teheran to Esfahan, and a plan for balanced growth in support of environmental goals. The Delphi technique was used to arrive at a consensus of values that considered the magnitude and significance of the impact of each alternative. A similar study carried out for the upper Adriatic in Yugoslavia is also briefly described.

P.T.H.

A79-34181 Energy, helium, and the future. M. C. Krupka and E. F. Hammel (California, University, Los Alamos, N. Mex.). In: *Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 10.* Washington, D.C., Hemisphere Publishing Corp., 1978, p. 4989-5010. 24 refs.

The paper reviews developments in U.S. helium policy since 1975. Special attention is focused on the legal issues involved in the helium conservation program. Two court decisions have yielded a

range of \$0.60 to \$17.00 per Mcf helium. The higher price would entail an additional liability or additional storage cost for the Federal Government. The Bureau of Mines has maintained the position that it is authorized to assure a helium supply solely to meet Federal demand or 'essential government activities'. Thus the Bureau periodically requests both annual and five-year incremental projections of helium demand from agencies with major usage.

P.T.H.

A79-34182 Alternative energy sources; Proceedings of the Miami International Conference, Miami Beach, Fla., December 5-7, 1977. Volume 11 - Index. Conference sponsored by the U.S. Department of Energy and University of Miami. Edited by T. N. Veziroglu (Miami, University, Coral Gables, Fla.). Washington, D.C., Hemisphere Publishing Corp., 1978. 121 p. Price of eleven volumes, \$495.

A79-34192 Excited-state kinetics for Nd/thd/3 and Tb/thd/3 chelate vapors and prospects as fusion laser media. R. R. Jacobs and W. F. Krupke (California, University, Livermore, Calif.). *Applied Physics Letters*, vol. 34, Apr. 15, 1979, p. 497-500. 12 refs. Contract No. W-7405-eng-48.

A79-34253 Feedback control of a class of plasma instabilities. A. K. Sen (Columbia University, New York, N.Y.). *IEEE Transactions on Automatic Control*, vol. AC-24, Apr. 1979, p. 272-276. 12 refs. NSF Grant No. ENG-74-10444-A01.

The paper discusses feedback control of an important class of plasma instabilities consisting of drift waves, some flutes, and trapped particle modes. These instabilities, which have discrete spectra involving a reasonable number of modes, are for all practical purposes shown to be completely observable and controllable with a single internal sensor and single suppressor. The paper develops detailed stabilizing feedback controllers for a multimode collisional drift wave instability in a Q-machine and for a dissipative trapped electron mode in a linear machine.

B.J.

A79-34276 Effects of energy conservation research, development, and demonstration on residential energy use. E. Hirst (Oak Ridge National Laboratory, Oak Ridge, Tenn.). *Energy Systems and Policy*, vol. 3, no. 1, 1979, p. 37-59. 16 refs. Research sponsored by the U.S. Department of Energy.

The Oak Ridge National Laboratory residential energy model is used to evaluate the energy and direct economic effects of offering new technologies for providing residential services (e.g., space heating, water heating). These new technologies are assumed to be introduced as a consequence of government and private research, development, and demonstration (RD&D) programs. The energy savings resulting from the new technologies considered here increase from 0.1 QBtu in 1980 to 0.9 QBtu in 1990 and 1.9 QBtu in 2000. Present and projected RD&D programs sponsored by the Department of Energy (DOE) are expected to account for one-third of the cumulative energy saving of 20 QBtu. Because these new systems are more energy efficient than the conventional systems they replace, household fuel bills are reduced by \$20 billion between 1977 and 2000. On the other hand, the higher initial cost of these advanced systems increases consumer costs on new equipment and structures. The net economic benefit to the nation's households is almost \$18 billion. The DOE programs account for about 40% of this dollar saving.

(Author)

A79-34277 Three modes of energy cost analysis - Then-current, base-year, and perpetual-constant dollar. R. M. Harnett (Clemson University, Clemson, S.C.) and D. L. Phung (Oak Ridge Associated Universities, Oak Ridge, Tenn.). *Energy Systems and Policy*, vol. 3, no. 1, 1979, p. 61-72. Contract No. EY-76-C-05-0033.

This paper presents three modes of energy cost analysis and explores their interrelationships through algebraic discussions and numerical examples taken from ten synthetic fuel energy technologies. The depreciable capital component of total cost is analyzed for the technologies using preliminary estimates of their costs and performances. The numerical examples show that the three modes of analysis, when used with properly adjusted discount rates, produce the same ranking of the technologies. (Author)

A79-34278 Rationing energy to industries - Priorities and input-output dependence. T. L. Saaty (Pennsylvania, University, Philadelphia, Pa.) and R. S. Mariano (British Columbia Telephone Co., Canada). *Energy Systems and Policy*, vol. 3, no. 1, 1979, p. 85-111. 19 refs.

Allocation of electricity to industries in case of shortfall according to the priorities of their contributions to national welfare as defined by several (economic, political and social) criteria is studied and illustrated using the recently developed theory of analytic hierarchies. Here we apply the method to deal with problems of multicriterion decision making by considering qualitative and quantitative factors. Optimum allocation is made by linear programming subject to input-output constraints among the industries. (Author)

A79-34281 Composite-rim flywheels - Spin tests. E. D. Reedy, Jr. and H. K. Street (Sandia Laboratories, Albuquerque, N. Mex.). *SAMPE Quarterly*, vol. 10, Apr. 1979, p. 36-41. 8 refs. Contract No. AT(29-1)-789.

Two composite-rim flywheels of a size appropriate for use in a hybrid vehicle were designed. Each design employed a different method of utilizing Kevlar 49/epoxy bands to attach the rim to an aluminum hub. Four prototype flywheels, two of each design, have been fabricated and spin tested. (Author)

A79-34285 Radioisotope-powered photovoltaic generator. J. W. McKlveen (Arizona State University, Tempe, Ariz.) and J. Uselman (General Electric Co., Nuclear Energy Divs., San Jose, Calif.). *Nuclear Technology*, vol. 43, May 1979, p. 366-372. 6 refs.

Disposing of radioactive wastes from nuclear power plants is discussed through the radioisotope-photovoltaic-generator concept (RPG). In the generator, a portion of the waste ^{90}Sr and ^{238}Pu would be used in conjunction with a scintillation material to produce light, with subsequent conversion into electricity via photovoltaic cells. Three types of scintillators and two types of silicon cells were tested in six combinations using ^{32}P as the radioisotope. The highest system efficiency, determined to be 0.5% when the light intensity is normalized to 100 mW/sq cm, was obtained by using a CsI crystal scintillator and a Helios photovoltaic cell. A.A.

A79-34372 Second stage concentration with tapers for fluorescent solar collectors. A. Goetzberger and O. Schirmer (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, Institut für Angewandte Festkörperphysik, Freiburg im Breisgau, West Germany). *Applied Physics*, vol. 19, May 1979, p. 53-58. 5 refs.

Light concentration of fluorescent sheet collectors can be enhanced by providing the output edges with a taper of a higher refractive index with reflecting surfaces. Concentration ratios achievable by this means are computed for two shapes of tapers, one with a plane boundary towards the collector and one with an additional cylindrical lens. The general limitation of concentration ratio is given by Liouville's theorem or Abbe's sine condition. Computed second stage concentration ratios are: (1) For plane boundary taper, refraction index of the collector equal to 1.5, refraction index of the wedge equal to 2 and three reflections in the taper, the concentration ratio is equal to 1.49, and (2) for the lens-taper combination under the same conditions, the concentration ratio is equal to 1.76 nearly reaching the Liouville limit, 1.79. (Author)

A79-34389 Energy sources of the future - A challenge to man's ingenuity. A. Garratt. *Radio and Electronic Engineer*, vol. 49, Apr. 1979, p. 175-180. 15 refs.

The reserves of fossil fuels are analyzed and some of the methods being developed to improve the energy yield from existing reserves are looked at, including enhanced oil recovery and magneto-hydrodynamics. Other sources of energy not relying on fossil fuels are considered. Some could be tapped immediately or with some straightforward development, e.g., nuclear fission, solar, tidal and wave power. A proposed 2MW French prototype solar power station under construction in the Pyrenees is described. Future large-scale production of power by deep gasification of coal and by nuclear fusion are discussed and their role as potential replacements for coal, gas and oil are considered. (Author)

A79-34400 Magnetic instability of laser-produced plasma and spontaneous generation of magnetic fields. A. Sh. Abdullaev, Iu. M. Aliev, V. Iu. Bychenkov (Akademii Nauk SSSR, Fizicheskii Institut, Moscow, USSR), and V. Stefan (Institut za Nuklearne Nauke, Belgrade, Yugoslavia). *Physics Letters*, vol. 71A, Apr. 16, 1979, p. 63-65. 8 refs.

A79-34449 Solar energy conversion: The solar cell. R. C. Neville (California, University, Santa Barbara, Calif.). Amsterdam, Elsevier Scientific Publishing Co. (Studies in Electrical and Electronic Engineering. Volume 1), 1978. 307 p. 383 refs. \$59.18.

The book is a survey-test that explores a number of critical background fields or areas and then outlines the theory of operation of solar cells. Solar cell performance is treated both in the general sense and for some specific cases. The 'energy crisis', the nature of the solar spectrum, and physics of semiconductors for use in solar cells are surveyed. The interaction of light and semiconductors is treated, including absorption, reflection and transmission. A general discussion of methods for solar cell construction is presented, along with illustrative examples to provide specific values of solar cell performance based on particular technologies of junction fabrication and solar cell optical orientation. Also discussed are the effects on solar cell operation of increased (above 300 K) temperature and the use of concentrated sunlight. Economics and system problems inherent in the use of solar cells are also considered. S.D.

A79-34451 American Power Conference, Illinois Institute of Technology, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Conference sponsored by the Illinois Institute of Technology. Edited by B. Haigh. Chicago, Illinois Institute of Technology, 1978. 1550 p. \$30.

Cogeneration plants for steam and electric production, solar power stations, open-cycle coal-fired MHD power plants, flue gas desulfurization, hydroelectric power, and mechanical energy storage systems are discussed. Topics of the papers include stabilization of flue gas desulfurization sludge, a 10-MWe solar power station, simple techniques for estimating the economic advantages of cogenerating facilities, a Lurgi-process coal gasification installation integrated with a combined-cycle electrical generation plant, power distribution planning, the control of corrosion in boiler water systems, and fatigue failure of turbine-generator shafts. J.M.B.

A79-34452 Energy conserving cogeneration plant benefits utility and industrial companies. M. R. Hale (Applied Energy, Inc., San Diego, Calif.) and J. C. Solt (Solar Turbines International, San Diego, Calif.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 349-356.

A cogeneration plant capable of providing as much as 800 kW of electricity and 7000 lb per hour of 15 psig, saturated steam has been put into operation. The heat source for the cogeneration plant is a combustion turbine-generator fueled by diesel oil. As opposed to separate conventional steam and electric generation, the cogeneration facility will provide a fuel saving of 25%. Cogeneration schemes for direct-heat drying and heat-exchange applications are also considered. J.M.B.

A79-34453 What is the true cost of electric power from a cogeneration plant. W. H. Comtois (Westinghouse Electric Corp., Pittsburgh, Pa.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 357-366.

Cogeneration plants based on backpressure or combustion turbines are described, and the economics of cogeneration facilities are analyzed. The backpressure turbine design requires higher than normal exhaust pressures and does not include a condenser; the simplicity of this design has made it the favored installation for development. A direct method for determining the savings that result from joining power and steam production into a cogeneration unit is presented. Economic advantages of cogeneration facilities serving industry but owned by a utility are also considered. J.M.B.

A79-34454 The Powerton gasification combined-cycle test facility - A preview. F. E. Stauffer, D. E. Welty (Commonwealth Research Corp., Chicago, Ill.), A. Sacker (Fluor Engineers and Constructors, Inc., Irvine, Calif.), and W. A. Boothe (General Electric Co., Schenectady, N.Y.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 429-434.

A demonstration power plant integrating coal gasification and combined-cycle electrical generation is under development. The gasification facility will use the Lurgi process to convert coal into a clean, low-Btu fuel gas. The combined-cycle plant will provide an efficient source of air and steam for the gasification facility. Since the fuel gas will have an adiabatic flame temperature lower than natural gas or distillate fuels, combustion will result in a low production rate for oxides of nitrogen. Because of the elevated mass flow rate of the low-Btu gas, the turbine performance is expected to be high. J.M.B.

A79-34455 A central receiver solar thermal power system. W. R. Lang (Stearns-Roger, Inc., Denver, Colo.) and R. G. Riedesel (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 448-456.

A 10-MWe power plant based on a solar collector system with a central receiver is under development. The pilot plant features an array of heliostats (tracking mirrors) which reflect solar radiation onto a receiver/boiler. Steam from the boiler may be used in a conventional turbine-generator set, routed to a thermal storage facility, or both. The thermal storage facility contains high-temperature oil and rocks to store thermal energy for steam generation during periods of little or no solar radiation. J.M.B.

A79-34456 Engineering studies of open-cycle coal-fired MHD for power generation. F. D. Retallick and T. E. Lippert (Westinghouse Electric Corp., Pittsburgh, Pa.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 457-463.

Open-cycle coal-fired MHD-steam power plants offer a high fuel conversion efficiency and competitively priced electricity. Characteristics of MHD plants are discussed as a function of nominal thermal rating; the development of effective high-temperature air heaters is seen as a chief need for commercial MHD plants. A number of options for open-cycle MHD plants are reviewed: combustor temperature, combustor and channel designs, magnet parameters, sulfur removal techniques and seed recovery schemes. J.M.B.

A79-34457 Advanced power cycles and their potential for electrical energy generation. G. R. Fox (General Electric Co., Schenectady, N.Y.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 464-478.

The economics and performance of energy conversion systems utilizing advanced cycles based on coal or coal-derived fuels are analyzed; attention is given to steam cycles, combined-cycle gas

turbine systems, and closed-cycle helium gas turbines with atmospheric fluidized-bed furnaces. Thermodynamic cycle peak temperatures of several of the advanced systems described here exceed those of plants currently in operation. In general, the advanced energy conversion systems meet environmental standards with high efficiency. J.M.B.

A79-34458 Technical and economic factors for evaluating flue gas desulfurization technologies. L. J. Adams (Mid-Valley, Inc., Oakbrook, Ill.), A. A. Ramirez (FMC Corp., Environmental Equipment Div., Itasca, Ill.), and N. P. Wagner (Southern Indiana Gas and Electric Co., Evansville, Ind.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 602-610. 16 refs.

Flue gas desulfurization (FGD) schemes have been investigated for a 250-MW pulverized-coal-fired boiler which will use high-sulfur coal (a maximum of 4.5% sulfur content). Limestone, lime, and double-alkali schemes were evaluated. Among the features considered in examining the proposals were liquid-to-gas ratios, chemical consumption, power consumption, pressure drop across the system, the quantity and quality of the waste sludge, and the maintenance requirements of the schemes. According to the evaluation, the double-alkali system provides the most efficient absorption capability, together with low maintenance. Reagent costs for lime and double-alkali schemes are approximately equivalent. J.M.B.

A79-34460 Options for treating and disposing of scrubber sludge. R. W. Goodwin and R. J. Gleason (Research-Cottrell, Inc., Bound Brook, N.J.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 661-669. 13 refs.

Commercial systems for stabilizing flue gas desulfurization (FGD) sludge include forced oxidation, fixation, and blending with fly ash. Stabilization of the FGD waste makes long-range transportation of the material possible, and increases the disposability of the sludge. Sulfate sludge resulting from either blending or fixation exhibits greater strength than the untreated sulfate material. If suitable geological conditions exist, blended material can be used as land-fill. Fixation appears to be the best scheme for environmentally sensitive disposal locations. J.M.B.

A79-34461 Solid waste as a source of energy for industry - An overview. C. H. Leatham, Jr. and S. P. Gambhir (Gilbert/Commonwealth, Jackson, Mich.). In: American Power Conference, Chicago, Ill., April 24-26, 1978, Proceedings. Volume 40. Chicago, Illinois Institute of Technology, 1978, p. 825-833.

Solid waste processing facilities are discussed, with attention given to conventional incineration, burning after shredding, fluidized-bed incineration, hydropulping, pyrolysis, and the production of refuse-derived fuel. An incineration system capable of producing 185,000 lb/h of 690 psig, 875 F steam is described. Preincineration shredding, sizing and magnetic removal of ferrous metals are discussed; preincineration treatment is especially important for fluidized-bed schemes. Fuel derived from municipal refuse has been used to supply from 5 to 30% of the Btu requirements of a 250-MW pulverized-coal-fired boiler. J.M.B.

A79-34530 Chemical origin of the space-charge layer in cuprous oxide front-wall solar cells. J. Herion (Kernforschungsanlage Jülich GmbH, Institut für Grenzflächenforschung und Vakuumphysik, Jülich, West Germany). *Applied Physics Letters*, vol. 34, May 1, 1979, p. 599-601. 10 refs.

Auger electron spectroscopy was used to investigate the region near the front contact of cuprous oxide front-wall solar cells. In cells showing large photovoltages, a maximum of the copper concentration, about 4 at. % higher than the bulk concentration, was observed at a distance of 70 Å from the metal-semiconductor interface. If the

photovoltage was low a copper maximum adjacent to the interfacial layer was found instead. It is concluded that changes of the stoichiometry of cuprous oxide must be taken into account in order to explain the origin of the space-charge layer in Cu₂O front-wall cells. (Author)

A79-34601 Design study - Solar systems for commercial buildings. J. B. Bisset and P. F. Monaghan (Chorley and Bisset, Ltd., London, Ontario, Canada). (*American Society of Heating, Refrigerating and Air-Conditioning Engineers, Semi-Annual Meeting, Philadelphia, Pa., Jan. 28-Feb. 1, 1979.*) *ASHRAE Journal*, vol. 21, May 1979, p. 37-42. 20 refs. Research supported by the Public Works Canada, National Research Council, and Department of Energy, Mines and Resources of Canada.

A design study considering the use of solar energy for heating and cooling a hypothetical, 11 story, downtown office building in Ottawa, Canada is presented. Five mechanical systems are given in detailed concept design. Two are conventional and three are solar assisted, with solar-assisted heat pump systems and solar absorption cooling included in the solar concepts. Manual calculation methods were used to estimate the solar energy collected, and construction and energy costs for alternatives were calculated at present day costs. Results indicated that a solar-assisted heat pump system is the most attractive energy conserving system. M.E.P.

A79-34602 A retrofitted geothermal heating system. G. Hull and G. Simmons (Idaho, University, Moscow, Idaho). *ASHRAE Journal*, vol. 21, May 1979, p. 45-50. 11 refs. Research supported by the Pacific Northwest Regional Commission.

The recent conversion of the Idaho State Health and Agricultural Laboratory to geothermal heating is presented. Computer simulation was used to analyze the system which exchanges the geothermal energy with a sealed water system. Set point temperature was reduced from 155 F to 135 F which is generally sufficient, thereby reducing energy use. Other benefits were an increase in energy obtained from the geothermal water minimizing usage of the water, and reduced thermal pollution effect of the discharged water. In order that geothermal flow be minimized two general rules should be followed: (1) eliminate waste by insulating all distribution pipelines and properly sizing heat exchangers, (2) extract the maximum energy from each gallon of geothermal water by discharging the water at the lowest possible temperature. M.E.P.

A79-34610 Thin-film solar cells - A chance to convert economically solar energy into electric energy (Dünnschichtsolarelemente, eine Chance, Sonnenenergie wirtschaftlich in elektrische Energie umzuwandeln). H. Frey (Baden-Württemberg, Berufsschule, Karlsruhe, West Germany) and K. Radler (Deutsches Elektronen Synchrotron, Hamburg, West Germany). *VDI-Z*, vol. 121, no. 8, Apr. 1979, p. 389-393. 6 refs. In German.

Solar generators for converting sunlight into electrical energy are discussed, with emphasis on the construction of cost effective solar cells. Calculations of costs, performed by various institutions, are considered, showing that presently it is not possible to generate economically electrical energy by means of solar-electric power stations. Technological developments leading to large-scale production of cost effective thin-film solar cells are reviewed. The steady rise in energy costs, and the technological and ecological problems associated with nuclear energy are noted. A.A.

A79-34738 * # Solar thermoelectric power generation for Mercury orbiter missions. M. Swerdling (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and V. Raag (Synical Corp., Sunnyvale, Calif.). In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 306-314. 8 refs. Contract No. NAS7-100. (AIAA 79-0915)

Mercury orbiter mission study results have shown that conventional silicon solar cell array technology is not adequate to produce

power because of expected temperatures which range from -90 C to +285 C in about 50 minutes for 16 sun eclipses/day. The solar thermoelectric generator (STG), which requires relatively high temperatures, is being developed as a replacement power source. Several thermoelectric technologies (i.e., lead telluride alloys, bismuth telluride, selenide, and silicon-germanium alloys have been examined for their suitability. Solar concentrator configurations (i.e., flat plate, Fresnel lens, mini-cone, and Cassegrain types) were also studied as candidates for increasing incident radiation during Mercury orbital operations. Detailed results are presented, and show that an STG design based on the use of silicon-germanium alloy thermoelectric material and using high-voltage thermopiles with individual miniconical concentrators presents the optimum combination of technology and configuration for minimizing power source mass. (Author)

A79-34739 * # Synchronous orbit power technology needs. L. W. Slifer, Jr. (NASA, Goddard Space Flight Center, Power Applications Branch, Greenbelt, Md.) and W. J. Billerbeck (COMSAT Laboratories, Clarksburg, Md.). In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1979, p. 315-323. 16 refs. Research supported by COMSAT Laboratories and NASA. (AIAA 79-0916)

An attempt is made to define the needs for future geosynchronous spacecraft power subsystem components, including power generation, energy storage, and power processing. Three projected models (a mission model, an orbit transfer vehicle model, and a mass model) for power subsystem components are used to define power requirements and mass limitations for future spacecraft. Based upon these models, the power subsystems for a 10-kW, 10-year-life, dedicated spacecraft and for a 20-kW, 20-year-life multimission platform are analyzed to establish power density requirements for orbit transfer vehicles. Comparison of these requirements to state-of-the-art (Intelsat 5) design values shows that major improvements, by a factor of 2 or more, are needed to accomplish the near term missions. B.J.

A79-34775 * # Large space system - Charged particle environment interaction technology. N. J. Stevens, J. C. Roche, and N. T. Grier (NASA, Lewis Research Center, Cleveland, Ohio). In: Conference on Advanced Technology for Future Space Systems, Hampton, Va., May 8-10, 1979, Technical Papers. New York, American Institute of Aeronautics and Astronautics, Inc., 1979. 21 p. 31 refs. (AIAA 79-0913)

Large high-voltage space power systems proposed for future applications in both low earth orbit and geosynchronous altitudes must operate in the space charged-particle environment with possible interactions between this environment and the high-voltage surfaces. The paper reviews the ground experimental work to provide indicators for the interactions that could exist in the space power system. A preliminary analytical model of a large space power system is constructed using the existing NASA Charging Analyzer Program, and its performance in geosynchronous orbit is evaluated. The analytical results are used to illustrate the regions where detrimental interactions could exist and to establish areas where future technology is required. S.D.

A79-34828 * # Excavation costs for lunar materials. W. D. Carrier, III (Bromwell Engineering, Lakeland, Fla.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 79-1376*. 9 p. NASA-supported research.

A lunar strip mining system is presented which is capable of excavating and transporting 3 million metric tons of ore per year to a central processing plant on the moon's surface. The mining system would grow from a single front-end loader in the first year, to a fleet of ten haulers in the 30th year. Lunar personnel requirements would

consist of a single individual, whose primary function would be to perform maintenance. All of the mining equipment would either operate automatically or by remote control from earth. The projected cost for the lunar mining system is approximately \$12 to \$37 per ton of ore over the life of the mine, an important part of the overall economics of exploiting lunar resources. (Author)

A79-34836 # Financing alternatives for space industrialization. J. P. Vajk (Science Applications, Inc., Pleasanton, Calif.), R. D. Stutzke (Science Applications, Inc., Colorado Springs, Colo.), M. S. Klan (Science Applications, Inc., Huntsville, Ala.), R. Salkeld, and G. H. Stine. *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 791389*. 15 p. 11 refs. Contract No. EG-77-C-01-4024.

Large scale space industrialization projects challenge conventional methods of financing commercial undertakings. As part of the Department of Energy's Satellite Power System Concept Evaluation Program, we examined the problems of financing both the lengthy and expensive R&D phase and the capital-intensive commercial implementation phase of an SPS program. Ten alternative schemes, ranging from purely public to purely private, were developed. One of these, a purely private enterprise approach, is already underway. Some of the alternatives presented here may be readily adapted to other space industrialization projects and to large-scale terrestrial projects as well. (Author)

A79-34840 * # Electromagnetic propulsion alternatives. H. Kolm, K. Fine, P. Mongeau, and F. Williams (MIT, Cambridge, Mass.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 79-1400*. 9 p. 26 refs. NASA-Army-supported research.

Mass drivers can serve to propel massive objects by expelling any available material as reaction mass, however, mass driver engines have several limitations such as relatively large payload size and dynamic stability problems. A number of alternative acceleration mechanisms exist which offer advantages for certain applications, such as higher acceleration at a sacrifice in efficiency, smaller possible size and decreased complexity at a sacrifice in service life, etc. The alternative concepts include several variants of the railgun, a family of superconducting slingshot oscillators, a momentum transformer, an impulse induction motor, and a family of hybrid synchronous accelerators. A potential application of considerable interest is the earth-based launching of space cargo or nuclear waste by using off-peak generating capacity to accelerate one ton cargo cylinders at intervals of several minutes. (Author)

A79-34844 * # Development of space manufacturing systems concepts utilizing lunar resources. E. H. Bock (General Dynamics Corp., Convair Div., San Diego, Calif.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 79-1411*. 8 p. NASA-sponsored research.

Results of a NASA sponsored study to evaluate the merits of constructing solar power satellites using lunar and terrestrial resources are reviewed. Three representative lunar resources utilization (LRU) concepts were developed and compared with a previously designed earth baseline concept, and major system hardware elements as well as personnel requirements were defined. LRU for space construction was shown to be competitive with earth baseline approach for a program requiring 10 to the 5th metric tons per year of completed satellites. Results also indicated that LRU can reduce earth launched cargo requirements to less than 10% of that needed to build satellites exclusively from earth materials, with a significant percentage of the reduction due to the use of liquid oxygen derived from lunar soil. A concept using the mass driver to catapult lunar material into space was found to be superior to the other LRU logistics techniques investigated. A.A.

A79-34845 # Lunar resources utilization - An economic assessment. R. C. Risley (General Dynamics Corp., Convair Div., San Diego, Calif.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 79-1412*. 8 p. 20 refs.

In this paper, a solar power satellite program scenario was analyzed to determine the economic viability of using lunar resources for manufacturing and constructing large structures in space. Three concepts featuring lunar resource utilization (LRU) were derived and compared with a NASA/JSC-furnished earth baseline concept. The economic assessment of the alternatives included cost determination, economic threshold sensitivity to manufacturing cost variations, cost uncertainties, program funding schedule, and present value of costs. It was found that LRU is potentially more cost-effective than earth-derived material utilization, depending upon such factors as the efficiency of the facilities and the manufacturing chain as well as the type of scenarios. Because of the uncertainties, cost-effectiveness cannot be ascertained with great confidence. The probability of LRU attaining a lower total program cost within the 30-year program appears to range from 57 to 93 percent. (Author)

A79-34846 # New methods for the conversion of solar energy to R. F. and laser power. J. W. Freeman, W. B. Colson, and S. Simons (Rice University, Houston, Tex.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 791416*. 7 p. 8 refs.

This paper discusses two new devices which may have application to space deployed solar energy conversion and transmission systems, the photoklystron and the free electron laser. The photoklystron converts solar energy directly to RF radiation. It operates on the principle of the klystron with the cathode replaced by a photoemitting surface. We have tested a model which oscillates at 30 MHz. This laboratory model requires two low-voltage bias voltages which can be supplied by dc solar cells. Concepts for a self-biasing device are also being considered. The photoklystron is expected to be easier and less expensive to manufacture than solid state solar cells. A photoklystron array could replace the high voltage solar cell array, slipring and klystron transmitter in the SPS. The second device, the free electron laser (FEL), converts energy from a relativistic electron beam to narrow band electromagnetic energy, tuneable from the infrared to the ultraviolet. Because the lasing electrons are not bound in atomic energy levels the ultimate efficiency of the FEL is expected to exceed that of conventional lasers, possibly making lasers a practical means of energy conversion and transmission in space systems. (Author)

A79-34848 # Solar Power Satellite beam disturbance of the upper ionosphere. J. E. Drummond (Power Conversion Technology, Inc., San Diego, Calif.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 79-1422*. 5 p. 9 refs.

Interaction of the microwave beam from a Solar Power Satellite with earth's ionosphere produces, according to theory, an amplifying system. What is amplified is a pattern of ripples which may exist in ionization density at the top of the ionosphere. Such ripple patterns are formed evidently in association with aurora. The question is, how does the gain of this system depend upon ripple wave length and power in the beam. So far a fairly broad maximum has been found at a ripple period of about 70 meters. The amplification of an auroral 'curtain' extending from 230 to 330 km would be about 8000. This would turn a barely detectable 0.01% ripple into an 80% modulation of electron density at the bottom of the ionosphere if the nonlinear growth followed the linear pattern. Such a modulation would produce a Fresnel lens which would cause east-west deflections of the beam by several kilometers. Laboratory experiments to test the basic mechanisms have begun at PCT. (Author)

A79-34849 # Atmospheric attenuation of centimeter microwaves. W. Ziegler (Sigma Data Services Corp., New York, N.Y.). *Princeton University and American Institute of Aeronautics and Astronautics, Conference on Space Manufacturing Facilities, 4th, Princeton University, Princeton, N.J., May 14-17, 1979, AIAA Paper 79-1423.* 10 p. 45 refs.

The purpose of this paper is to review the literature on absorption and scattering of centimeter microwaves in the troposphere. Theoretical and measured values for absorption and scattering are applied to the case of a Microwave Power Transmission System to determine possible atmospheric heating and loss of power from the beam. (Author)

A79-34860 * The future United States space program; Proceedings of the Twenty-fifth Anniversary Conference, Houston, Tex., October 30-November 2, 1978. Parts 1 & 2. Conference sponsored by the American Astronautical Society, Boeing Co., General Electric Co., IBM Corp., Lockheed Electronics Co., Northrop Services, Inc., Technology, Inc., and NASA. Edited by R. S. Johnston (NASA, Johnson Space Center, Houston, Tex.), A. Naumann, Jr. (Lockheed Electronics Co., Inc., Plainfield, N.J.), and C. W. G. Fulcher (General Electric Co., Fairfield, Conn.). San Diego, Calif., American Astronautical Society (Advances in the Astronautical Sciences, Volume 38, Pts. 1 & 2); Univelt, Inc., 1979. Pt. 1, 442 p.; pt. 2, 432 p. Price of two parts, \$80.

Space Shuttle guidance problems, solar power satellites, space law, satellite communications, space medicine, and engineering of large space systems are discussed. Topics of the papers include biological experiments designed for the Space Shuttle, an optimized guidance law for Space Shuttle re-entry, aircraft propulsion based on laser energy, industrial materials available in the lunar soil, health programs for a solar power satellite construction team, closed life support systems for large habitats in space, the advantages of a manned mission to Mars, the interpretation of radar imagery of Venus, a cost analysis for the satellite power system, and the geological history of Mars. J.M.B.

A79-34862 The polar lunar base - A viable alternative to L-5. J. Green (California State University, Long Beach, Calif.). In: *The future United States space program; Proceedings of the Twenty-fifth Anniversary Conference, Houston, Tex., October 30-November 2, 1978. Part 1.* San Diego, Calif., American Astronautical Society; Univelt, Inc., 1979, p. 385-425. 120 refs. (AAS 78-191)

A lunar polar station offers solar power for the earth as well as solar power to process raw materials on the moon. A polar site 630 m above the mean lunar surface is always in sunlight. From a polar site, one solar collector measuring 12 by 2.5 km could microwave 1.5 billion cal per second to the earth. Power from solar panels at the lunar pole could also be used to process ore mass-launched to the poles from optimum sites on the moon. Lunar ores include anorthosite for aluminum; ilmenite for iron; titanium and native iron; and basalt for casting, sintering and spinning. Volcanic terrains may offer many of the resources from optimum sites on the moon to a polar lunar base. Comparisons between this base and the L-5 Lagrangian point are quantified. (Author)

A79-34864 Solar power space stations - Some issues of law and policy. S. Gorove (Mississippi University, University, Miss.). In: *The future United States space program; Proceedings of the Twenty-fifth Anniversary Conference, Houston, Tex., October 30-November 2, 1978. Part 2.* San Diego, Calif., American Astronautical Society; Univelt, Inc., 1979, p. 595-599. 6 refs. Contract No. EG-77-C-01-4024. (AAS 78-199)

Some of the legal problems associated with solar power space stations are discussed. Emphasis is placed on a critical examination of relevant provisions of international space law. The recent claims of equatorial countries embodied in the Bogota Declaration of 1976 are discussed. Pertinent major legal and policy issues are highlighted.

S.D.

A79-34865 Future programs in space. J. A. Snow (U.S. Department of Energy, Office of Energy Research, Washington, D.C.). In: *The future United States space program; Proceedings of the Twenty-fifth Anniversary Conference, Houston, Tex., October 30-November 2, 1978. Part 2.* San Diego, Calif., American Astronautical Society; Univelt, Inc., 1979, p. 689-703. (AAS 78-180)

There are a variety of areas in which space has the potential for contributing to the future well-being of the United States and the world. It has been evident - even before the current intense focus on energy problems - that remote sensing from aircraft and spacecraft can make significant contributions to energy, as related to exploration, extraction, power plant siting, environmental monitoring and assessment, and applications for developing nations. A discussion of requirements for implementation of satellite power systems reveals that there is a potential future for a vastly abundant supply of energy through the satellite power system. The U.S. civil space policy is also examined. S.D.

A79-34987 # A profile of power transmission by microwaves. W. C. Brown (Raytheon Co., Microwave and Power Tube Div., Lexington, Mass.). *Astronautics and Aeronautics*, vol. 17, May 1979, p. 50-55. 9 refs.

The technical character of free-space microwave transmission, an efficient means of point-to-point transfer of energy through free space using a highly collimated microwave beam, is explained. The principal features of the method are examined, noting that (1) it needs no mass between the source of energy and the point of consumption, (2) energy is transferrable at the velocity of light, (3) the direction of energy transfer can be changed by repointing the transmitting antenna, (4) the system does not lose energy in its transfer through the vacuum of space, and (5) the mass of the conversion devices at the transmitting and receiving points can be kept small. The key processes associated with microwave-power transmission, including conversion of large amounts of d.c. into microwave power, and absorption of the microwave power at the receiving aperture, are described. Requirements of the receiving portion of the microwave power system are reviewed, together with an examination of the rectenna concept. A.A.

A79-34989 Hydrogen isotope distillation for fusion power reactors. J. R. Bartlit, R. H. Sherman, R. A. Stutz (California University, Los Alamos, N. Mex.), and W. H. Denton (Atomic Energy Research Establishment, Harwell, Berks., England). *Cryogenics*, vol. 19, May 1979, p. 275-279. 11 refs.

A description is presented of the functions and design of a computer-controlled system of four, interlinked, cryogenic, fractional distillation columns capable of separating a feed-stream of mixed isotopes (hydrogen, deuterium, and tritium) into four high-purity product streams needed in the development of a D-T fueling system for fusion power reactors. The packed columns, each 19.38 mm ID by 3.2-4.1 m high and together served by a single 450 W, 20 K refrigerator, are sized to process a feed of 360 g-mol per day of nominally 50-50 D-T, but containing all six diatomic isotopic species. The system also contains two room temperature catalytic equilibrators for promoting the reversible reaction: $HT + D_2$ yielding $HD + DT$. Full-scale system tests are scheduled for 1980. (Author)

A79-35038 Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Seminar sponsored by the Institute of Environmental Sciences, NBS, U.S. Department of Energy, and ASTM. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978. 277 p. \$22.

Testing of photovoltaic arrays, solar thermal power facilities, ocean thermal energy conversion (OTEC) systems, wind turbines, and solar heating and cooling systems is discussed; attention is also given to radiometer and pyroheliometer calibration. Topics of the

papers include lifetime predictions for low-cost photovoltaic arrays, a dual-medium thermal storage unit for a solar electric generating plant, actinometric measurement of solar UV, the high-temperature behavior of alumina-silica and zirconia board materials employed in solar concentrators, biofouling of heat exchangers in OTEC plants, a 5-MW solar thermal test facility, and a comparison of radiometer response to outdoor solar radiation and indoor simulated solar radiation. J.M.B.

A79-35039 * # Environmental testing of flat plate solar cell modules. J. Griffith, L. Dumas, and A. Hoffman (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 1-11.

Commercially available flat-plate solar cell modules have been subjected to a variety of environmental tests designed to simulate service conditions. Among the tests are those simulating heat and rain, wind-driven rains, humidity and freezing, humidity and heat, humidity with a voltage bias, salt fog, hail impact, and fungus infestation. Tests for optical surface soiling and the combined effects of temperature, humidity and UV irradiation are under development. A correlation has been demonstrated between degradation caused by the qualification tests and such observed field effects as power loss. J.M.B.

A79-35040 Sandia's photovoltaic test experience. J. L. Watkins (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 12-17. Research supported by the U.S. Department of Energy.

Testing of a variety of photovoltaic arrays, including compound parabolic concentrators, a two-axis tracking concentrator array, high-concentration arrays, and a Fresnel lens concentrating array is reported. Long-term output of the solar energy systems is monitored by an array loading device which consists of a logic and control module and a power dissipation module. Photographic records of the arrays provide a means of assessing visible degradation. In addition, hail impact tests, temperature/humidity cycling and UV irradiation exposure tests have been carried out on the photovoltaic arrays. J.M.B.

A79-35041 * # A life prediction methodology for encapsulated solar cells. C. D. Coulbert (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 18-23.

This paper presents an approach to the development of a life prediction methodology for encapsulated solar cells which are intended to operate for twenty years or more in a terrestrial environment. Such a methodology, or solar cell life prediction model, requires the development of quantitative intermediate relationships between local environmental stress parameters and the basic chemical mechanisms of encapsulant aging leading to solar cell failures. The use of accelerated/abbreviated testing to develop these intermediate relationships and in revealing failure modes is discussed. Current field and demonstration tests of solar cell arrays and the present laboratory tests to qualify solar module designs provide very little data applicable to predicting the long-term performance of encapsulated solar cells. An approach to enhancing the value of such field tests to provide data for life prediction is described. (Author)

A79-35042 * Measurement requirements and techniques for degradation studies and lifetime prediction testing of photovoltaic modules. G. T. Noel, F. A. Sliemers, G. C. Derringer, V. E. Wood, K. E. Wilkes, G. B. Gaines, and D. C. Carmichael (Battelle Columbus Laboratories, Columbus, Ohio). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 24-29. Research supported by the U.S. Department of Energy; Contract No. NAS7-100.

Tests of weathering and aging behavior are being developed to characterize the degradation and predict the lifetimes of low-cost photovoltaic arrays. Environmental factors which affect array performance include UV radiation, thermal energy, water, oxygen (generally involved in synergistic effects with UV radiation or high temperatures), physical stress, pollutants (oxides of nitrogen, sulfur dioxide and ozone), abrasives and dirt. A survey of photovoltaic array testing has shown the need to establish quantitative correlations between certain measurable properties (carbonyl formation, glass transition temperature, and molecular weight change) and modes of degradation and failure. J.M.B.

A79-35043 An approach for development of performance criteria and test standards in photovoltaics. G. Nuss (Solar Energy Research Institute, Golden, Colo.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 30-33.

The development of standards for photovoltaic arrays includes characterization of materials and components, establishment of the interchangeability of device components, specification of life expectancy/reliability levels, and description of safety characteristics of the arrays. Standards formulated by the DOE will lead to certification procedures; state and local regulatory agencies will be assisted in applying the standards. Photovoltaic array standards should also take into account the possible types of applications (small remote, marine, agricultural, or central power plant). J.M.B.

A79-35044 Concentrating solar collector test results from DOE/Sandia Collector Module Test Facility. V. E. Dudley (EG & G, Inc., Wellesley, Mass.) and R. M. Workhoven (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 34-38. 8 refs.

The performance of five solar collector modules (rotating mirror Fresnel reflector, fixed mirror Fresnel reflector, Fresnel lens rotating array, and two types of parabolic trough design) has been characterized. The performance tests were conducted over a temperature range of about 100 to 310 C at flow rates from about four to 10 liters/min; heat gain and efficiency calculations were carried out for each of the modules. Poor performance of optical material, thermal losses, and insufficient accuracy in constructing the components determining the optical path proved to be principal obstacles to high efficiency in the solar collectors. J.M.B.

A79-35045 Testing of central receiver for central thermal power systems. R. P. Pauckert, R. D. Tobin, and J. M. Friefeld (Rockwell International Corp., Rocketdyne Div., Canoga Park, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 39-44. Contracts No. EY-76-E-03-1108; No. E(04-3)-1103.

Testing of a central receiver, which absorbs solar radiation from a collector subsystem and converts the energy into superheated steam, is discussed. An external cylindrical receiver which employs a once-through flow circuit was selected for the test program. In terms of flow stability, as well as thermal, structural and control characteristics, the once-through steam generation concept proved to be feasible. In addition, it was concluded that graphite and/or Inconel radiant heaters could be used to simulate the heat flux levels produced by an actual heliostat array. Steady-state operation and the reaction of the receiver to flow cessation are described. J.M.B.

A79-35046 The DOE 5 MW Solar Thermal Test Facility. L. Matthews (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 45-49. 10 refs.

burg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 45-49.

The DOE 5-MW Solar Thermal Test Facility consists of a concrete tower with several test bays, 222 mirror assemblies (heliostats), as well as computer control and data acquisition systems. A heat rejection system capable of employing water or air as the primary fluid is also included in the facility. A collimated laser beam provides alignment for the heliostats; circular foil heat flux gages and photon sensors are adopted to measure flux density from the heliostats. A concentrator is available for experiments that require flux densities in the range of 10,000 Kw/sq m. J.M.B.

A79-35047 The development of the Advanced Components Test Facility. R. F. Altman and C. T. Brown (Georgia Institute of Technology, Atlanta, Ga.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 50-53.

A solar powered steam generator system with a unique mirror tracking mechanism and an antiradiating structure in the receiver is described. The tracking system requires no feedback system, either mechanical or electrical; a one and one-half horsepower electric motor provides power for a tracking system that can drive a mirror field of 550 heliostats. An antiradiating structure constructed of pyrex tubes is incorporated into the receiver design. The tracking heliostat array will also be tested with a ceramic air-cooled receiver and a sodium heat pipe receiver. J.M.B.

A79-35048 # White Sands solar test facility. R. A. Hays (U.S. Army, Nuclear Weapon Effects Laboratory, White Sands Missile Range, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 54-57.

The White Sands solar test facility includes a heliostat, attenuator, concentrator and test and control chamber. A total of 356 flat-plate mirrors mounted on a steel frame 1.2 by 11 m comprises the heliostat, which moves in azimuth + or - 60 deg and from zero to 90 deg in elevation. The concentrator is composed of 180 spherical mirrors mounted on a 9.1 sq m frame. The attenuator can vary the thermal power level of the facility from zero to maximum in two minutes. A maximum available flux of 100 cal/sq cm has been attained by the solar test facility. Cloud cover and wind are the chief operational constraints on thermal testing. J.M.B.

A79-35049 Sandia Laboratories' Midtemperature Systems Test Facility. R. M. Workhoven (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings.

Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 58-62. Research supported by the U.S. Department of Energy.

Four types of collector array, low- and high-temperature storage systems, a toluene heat exchanger and a turbine/generator set are the major components of a solar thermal power system which provides 70% of the peak heating and cooling demand of a 12,200 sq ft office building. The collector arrays in service at the test facility are a parabolic trough design, a parabolic dish module, a fixed mirror collector, and a solar linear-array thermal system. A collector module test facility capable of obtaining thermal and optical performance data for prototype collectors as large as 45 sq m in aperture is also described. J.M.B.

A79-35050 The real time aperture flux system as part of the Solar Thermal Test Facility. D. B. Davis and L. K. Matthews (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 63-68.

The real-time aperture flux system of the 5-MW DOE Solar Thermal Test Facility was developed to measure flux density in the

range from 40 to 4000 KW/sq m with an accuracy of 2 to 5%. The system is composed of thermal and photon sensors arranged on a moving bar; the sensors record the flux density in the aperture plane of a solar receiver. Reflecting gold plating on the sensors and an air and fluid refrigeration system maintain the sensors at sufficiently low temperatures during scans. J.M.B.

A79-35051 # Development of a dual-medium thermal storage system for solar turbo-electric power generation. G. R. Morgan, G. R. Schneider, and W. Unterberg (Rockwell International Corp., Rocketdyne Div., Canoga Park, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 69-74. Contract No. E(04-3)-1108.

A thermal storage subsystem has been tested for a 10-MW solar electric power plant. A dual-medium concept, which relies on both solid material (e.g. rock, ore, metal, brick or ceramic) and a liquid (such as water, petroleum products, heat transfer fluids or molten salts) for thermal storage, was adopted for the subsystem. The upper temperature limit for the thermal storage facility was set at 600 F; for power plants in the southwestern U.S., a six-hour storage capability has proved to be optimum. J.M.B.

A79-35053 * # Solar spectral irradiance at ground level. A. T. Medcherikunnel (NASA, Goddard Space Flight Center, Greenbelt, Md.) and J. C. Richmond (National Bureau of Standards, Washington, D.C.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings.

Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 83-107. 20 refs.

Available quantitative data on solar total and spectral irradiance is examined in the context of utilization of solar irradiance for terrestrial applications of solar energy. A brief review is given on the extraterrestrial solar total and spectral irradiance values. Computed values of solar spectral irradiance at ground level for different air mass values and various levels of atmospheric pollution or turbidity are also presented. Wavelengths are given for computation of solar absorptance, transmittance and reflectance by the 100-selected-ordinate method and by the 50-selected-ordinate method from air mass two solar spectral irradiance for the four degrees of atmospheric pollution. Total solar spectral irradiance measured with a prism monochromator is examined to evaluate the direct solar spectral irradiance for a surface normal to the sun's rays and to compare the computed spectrum with the experimentally observed one. (Author)

A79-35056 Solar radiation data modeling and its role in solar system studies. E. C. Boes (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings.

Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 117-124. 7 refs. Research supported by the U.S. Department of Energy.

A79-35057 # OTEC biofouling and corrosion testing program. E. H. Kinelski (U.S. Department of Energy, Div. of Solar Technology, Washington, D.C.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 125-128.

Corrosion and fouling by biological material could significantly degrade the heat transfer coefficients of ocean thermal energy conversion (OTEC) heat exchangers. Chlorination, water jets, and brushes propelled by a reversal of water flow are among the means proposed to lessen the detrimental effects of biofouling. A device to measure the influence of biofouling on heat transfer has been developed, and data have been obtained from a number of buoy- and barge-supported installations. Corrosion testing of titanium, aluminum and stainless steel, candidate materials for OTEC heat exchangers, is also mentioned. J.M.B.

A79-35058 **Testing the OTEC cold water pipe using the 'Deep Oil X-1' platform.** E. E. Horton, L. Pérez y Pérez (Deep Oil Technology, Inc., Long Beach, Calif.), and J. R. Paulling, Jr. (California, University, Berkeley, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 129-133.

An instrumented steel pipe five feet in diameter and 1000 feet in length will be used in a deep-sea test which is part of an ocean thermal energy conversion (OTEC) development program. The effect of platform motions, sea conditions and support systems on the dynamic behavior of the pipe will be studied. The experimental results can then be compared with motion and stress analyses conducted by linear frequency domain and nonlinear time domain techniques. J.M.B.

A79-35059 **Ocean Thermal Energy Conversion (OTEC) power plant instrumentation and measurement.** L. G. Lewis (Argonne National Laboratory, Argonne, Ill.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 134-138.

The primary goal of the OTEC program is to promote the use of the ocean thermal energy resource. The paper describes the measurements required in the power cycle, and to determine the accuracies needed to properly evaluate the effects of corrosion, fouling and cleaning. Instruments are discussed which can provide data for evaluating the performance of OTEC-1 heat exchangers when subjected to corrosion, biofouling, and cleaning. The accuracies obtainable for the calculated overall heat transfer coefficient and for gross power developed are adequate for the projected needs of the OTEC-1 program. The data obtained on OTEC-1 will be sufficient to predict the long-term performance of an OTEC power generating plant. S.D.

A79-35060 **OTEC-1 test conductor program.** P. Archbold and J. O. Bates (Energy Technology Engineering Center, Canoga Park, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 139-143.

The testing program which has been planned for the heat exchangers and auxiliary equipment of the preliminary ocean thermal energy conversion (OTEC) system sponsored by DOE is discussed. Test specifications and testing procedures for the cold water pipe, pumps, valves and the ammonia loop of the OTEC power plant are considered. Studies of biofouling and corrosion in the heat exchangers are also included in the OTEC testing program. J.M.B.

A79-35061 **The efficiency of solar assisted hot water systems.** J. Herlihy (Dayton T. Brown, Inc., Bohemia, N.Y.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 144, 145.

A79-35062 **Air collector testing utilizing ASHRAE 93-77.** R. D. Whitaker and W. T. Dokos (Desert Sunshine Exposure Tests, Inc., Phoenix, Ariz.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 146-151.

A facility and procedures have been developed for the testing of collectors that utilize air as the heat transfer medium. The facility is specifically designed for testing in accordance with the requirements of ASHRAE Standard 93-77 and capitalizes on the inherent advantages of a sun-tracking altazimuth mount and the open loop principle. A technique has been developed within DSET which expands upon the basic instantaneous efficiency measurement requirements of ASHRAE Standard 93-77 by accounting for the

effect of water vapor upon the specific heat and density of ambient air. This technique is based on the use of an enthalpy balance across the air collector's inlet and outlet and on precise air flow measurements obtained using laminar flow elements configured to measure both flow into and flow out of the collector. The effects of air leakage upon instantaneous efficiency test results are discussed.

(Author)

A79-35063 **Cost effective solar collector performance testing under combined indoor and outdoor conditions.** L. H. Usher (Wyle Laboratories, Solar Heating and Cooling Test Facility, Huntsville, Ala.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 152-155.

Descriptive information is provided on solar facilities and equipment currently operated by Wyle Laboratories to conduct thermal performance evaluation of solar energy industry products. This facility is designed to test residential, business and commercial solar heating and cooling systems and subsystems. The scope of testing discussed is limited to thermal performance evaluations of solar collectors using methods as advised in ASHRAE 93-77. The latest procedures are detailed which utilize combined indoor/outdoor facilities to improve the effectiveness of available equipment and manpower. Comparisons are made to show that combination of indoor and outdoor test facilities leads to better equipment utilization. S.D.

A79-35064 **Problems in collector testing.** G. R. Mather and D. C. Beekley (Owens-Illinois, Inc., Toledo, Ohio). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 156-158.

Problems associated with the thermal performance testing of solar collectors are discussed. ASHRAE 93-77 appears to be the collector test procedure which is the closest to being accepted on a consensus basis. The test procedures prescribed in this document do extend, through the incident angle modifier and time constant measurements, the data base beyond that of the Hottel-Whillier-Bliss equation. The discussion infers that three problems are apparent in the solar collector testing field: (1) diffuse insolation needs to be treated as a separate entity in test procedures; (2) the definition of the incident angle modifier needs to be generalized to encompass the focusing, geometric and optical phenomena occurring in collectors; and (3) performance data should be presented in a time frame of no less than one day. S.D.

A79-35065 **Correlation of instantaneous and all-day thermal performance of flat-plate solar collectors.** D. M. Deffenbaugh (Southwest Research Institute, Houston, Tex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 159-163

A79-35067 **Heliostat reflectivity variations due to dust buildup under desert conditions.** J. B. Blackmon and M. Curcija (McDonnell Douglas Astronautics Co., Huntington Beach, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 169-183.

A79-35068 **Exposure test results for reflective materials.** R. A. Rausch (Honeywell, Inc., Minneapolis, Minn.) and B. P. Gupta (Solar Energy Research Institute, Golden, Colo.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 184-187. NSF-ERDA-supported research.

Exposure tests have been conducted on a variety of candidate reflective materials for applications requiring concentration of solar

energy. Materials tested include aluminized fiberglass, aluminized acrylic, aluminized and silvered Teflon, aluminized and silvered glass, aluminized acrylic plexiglass, and anodized aluminum. Both first and second surface reflectors were included in the test samples. Three different, simultaneous exposure tests were conducted on the materials. Up to two and one-half years of real time exposure have been accumulated on most materials with reflectivity measurements at periodic intervals. With accelerated exposure tests, the samples have undergone an equivalent of 20 years solar exposure. The change in reflectivity with exposure time is presented for each of the materials and test conditions. (Author)

A79-35069 Specularity measurements by Fourier transform examination. H. L. Hampton, J. S. Hartman, and M. A. Lind (Battelle Pacific Northwest Laboratories, Richland, Wash.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 188-194. Contract No. EY-76-C-06-1830.

The paper describes how the Fourier transform technique can be used to examine the scattering properties or specularity of solar reflector materials, and discusses some instrumentation being developed to measure the effect. A typical optical system, consisting of a light source, an aperture, collimation optics, and collection optics, is assembled to demonstrate the usefulness of Fourier examination. It is shown that the examination of the Fourier transform of the reflectance function of optical materials is a powerful tool for evaluating the specularity characteristics of solar mirrors. Several methods for quantizing the intensity distribution of the light scattered into the Fourier plane are discussed. A two-dimensional image analysis device, such as a solid-state array, is presently not suitable for performing measurements on highly specular materials, and other detection schemes must be implemented. S.D.

A79-35070 High temperature materials study. L. Matthews (Sandia Laboratories, Albuquerque, N. Mex.) and G. P. Mulholland (New Mexico State University, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 195-200.

High-temperature insulating materials were tested in a solar furnace capable of attaining flux densities as high as 3750 kw/sq m. The tests involved subjecting each insulating material to an initial low flux density (approximately 500 kw/sq m), followed by increments of 250 kw/sq m to failure. Several alumina-silica board materials were found to fail at about the same flux density. Zirconia board failed at higher flux densities; however, it is more expensive than alumina-silica materials and not as workable. Refractory bricks showed very good performance in moderately high flux density domains. Analytical studies of the thermophysical properties of the insulating materials were also conducted. J.M.B.

A79-35071 Optical properties of materials under simulated operating environments. M. R. Jacobson (Arizona, University, Tucson, Ariz.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 201-205. NSF Grants No. AER-72-03566-A02; No. DMR-75-01267; Contracts No. EY-76-S-04-3709; No. EY-78-S-02-4399.

Facilities for measuring under simulated operating conditions the optical properties of selective coatings for dark mirrors used in photothermal solar energy conversion are presented. Hemispherical optical properties at different operational temperatures are measured by means of an integrating sphere reflectometer and high temperature spectrophotometer, and a cylindrical vacuum emissometer is under development. A proposed standardized measurement procedure includes nondestructive diagnostic measurements of reflectance, transmittance and hemispherical-directional reflectance of surfaces, followed by potentially destructive tests at high temperatures and a

simulation of operating conditions in the emissometer and life cycle furnaces and a post-testing inspection. The program is designed to aid in the development of new coatings, as well as to measure already developed surfaces. A.L.W.

A79-35072 Parameters, measurement and criteria of solar materials testing. J. E. Gilligan, J. E. Brzusiewicz, and J. M. Madigan (IIT Research Institute, Chicago, Ill.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 206-212. Contract No. EY-76-C-02-0578-034.

Optical property assessments of materials used in solar energy systems are discussed, with particular attention given to the geometries of optical measurements. In general, tracking collectors require less optical characterization than collectors with a fixed orientation. Bidirectional optical measurements, which take into account continuous changes in the solar vector as well as the directional dependence of optical properties, provide the most comprehensive means of assessing materials for solar energy systems. J.M.B.

A79-35073 # Solar energy systems - Survey of materials performance. L. F. Skoda and L. W. Masters (National Bureau of Standards, Gaithersburg, Md.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 213-217. 6 refs.

The need for standard ratings for materials employed in solar heating, cooling and domestic hot water systems is discussed. Problems noted in 25 operational solar energy systems include thermal decomposition of polymers in collectors, leakage from flexible couplings of transport piping, deterioration of tank insulation, and difficulties with pumps. Standard testing of materials used for absorptive coatings, collector insulation, cover plates, heat transport liquids, metallic containment, and seals is proposed. J.M.B.

A79-35074 # Degradation of polymethylmethacrylate by radiation. M. Abouelezz, L. Masters (National Bureau of Standards, Gaithersburg, Md.), and P. Waters (American University, Washington, D.C.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 218-223. 22 refs.

The stability of polymethylmethacrylate (PMMA) exposed to UV irradiation and simulated sunlight has been investigated in order to characterize the effectiveness of the material for solar energy collector cover plates. Rapid degradation of PMMA exposed to UV irradiation is noted; the initial and average rates of degradation produced by 253.7 nm lamps are greater than those caused by 300 nm lamps. The initial and average rates of degradation induced by xenon lamps are low. The degradation mechanisms associated with UV irradiation appear to be random scission and/or thermal degradation, while the mechanisms associated with xenon lamp irradiation are probably more complex. J.M.B.

A79-35075 SERI solar energy standards activities. H. Barker, J. Cattle, and G. Gross (Solar Energy Research Institute, Golden, Colo.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 224-228.

The activities of the Solar Energy Research Institute (SERI) in the area of the development and implementation of solar energy technology performance and reliability standards are discussed. The Analysis and Assessment division exists to assess the status of standards and codes which may affect the commercialization of solar technologies. The thermal performance of concentrating solar collec-

tors for implementation as sources of industrial heat in the range 100 to 300 C is studied by the Thermal Conversion branch of the SERI Research Division in order to develop standardized performance tests. Research directed toward improved methods for the prediction of system reliability from component and material performance information and toward improved methods for measuring and controlling degrading factors of environment and usage is planned.

A.L.W.

A79-35076 Cast acrylic Fresnel lenses for solar energy concentration. C. P. Lingle (Swedlow, Inc., Garden Grove, Calif.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 229-233. 11 refs.

The paper addresses the physical and mechanical characteristics of cast acrylic with emphasis on its use in Fresnel lens concentrators. Experimental evidence is presented which confirms that cast acrylic is resistant to long-term degradation (optical and physical) when subjected to field weathering conditions. Various configurations of acrylic Fresnel lenses that have been cast are examined in the context of their most common system applications. Other applications of cast acrylic are cited which also contain prolonged outdoor exposure and in which degradation would have impaired the material acceptability. The economic importance of weatherability is analyzed on a system life-cycle basis to demonstrate the significant advantages of cast acrylic over alternative materials.

S.D.

A79-35078 # Data acquisition and signal processing for a vertical axis wind energy conversion system. B. Stiefeld and R. N. Tomlinson (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 241-244. Research supported by the U.S. Department of Energy.

Data acquisition and analyses for a 17-m vertical-axis wind turbine system are discussed. The data acquisition system includes a pulse code modulated (PCM) multiplexer/encoder and an analog-to-digital converter subsystem. The PCM encoder, located on the turbine shaft near the measurement points, provides low-level structural data for the turbine facility. Data from the nonrotating portions of the facility are digitized with the analog-to-digital converter. Data can be analyzed on a real-time graphic display or stored on magnetic disks for long-term studies.

J.M.B.

A79-35079 # Photothermal conversion surface measurements using photoacoustic and photothermal spectroscopies. J. F. McClelland and R. N. Kniseley (U.S. Department of Energy, Ames Laboratory, Ames, Iowa). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 245-252. 18 refs. Research supported by the U.S. Department of Energy.

The photoacoustic and photothermal spectroscopic techniques are discussed in the context of photothermal conversion measurements. These methods are of particular interest in solar applications because they have a more direct connection to the photothermaliza-

tion process than reflectivity measurements due to the role of optical heating in the signal generation process. The photoacoustic and photothermal effects are examined and related to signal generation. A general signal expression is introduced and applied to solar absorber studies. An experimental apparatus is described and several prospective special applications are considered.

S.D.

A79-35082 Solar energy system testing - Some experiences with minicomputers. W. W. Shurtleff (Sandia Laboratories, Albuquerque, N. Mex.). In: Seminar on Testing Solar Energy Materials and Systems, Gaithersburg, Md., May 22-24, 1978, Proceedings. Mt. Prospect, Ill., Institute of Environmental Sciences, 1978, p. 265-269.

For the past few years, Sandia Laboratories has been involved with testing different components and systems associated with solar (and wind) energy studies. Sandia now has five minicomputer based controllers which aid in data acquisition and control of such projects as the Solar Total Energy Project, Photovoltaic Test Project, Solar Collector Project, Solar Thermal Test Facility (Power Tower), and the Vertical Axis Wind Turbine. The experiences associated with these projects have given some insight into developing a 'philosophy of application' of minicomputers or microprocessors to this type of testing. In this paper, such ideas as versatility of hardware and 'software' and 'distributed' systems are explained with the purpose of outlining this philosophy.

(Author)

A79-35171 # Prospects for developing a laser thermonuclear electric power plant (O perspektivakh sozdaniia lazernoi termoiadernoi elektrostantsii). N. G. Basov, O. N. Krokhin, V. B. Rozanov, A. E. Sheindlin, R. R. Grigor'iants, A. V. Kalinin, and E. E. Shpil'rain. *Akademii Nauk SSSR, Izvestiia, Energetika i Transport*, Mar.-Apr. 1979, p. 3-8. In Russian.

Fundamental problems in the design of a pure laser thermonuclear electric power plant are discussed. The parameters of the ideal laser system for such a plant are given, and the prospects for using a CO₂ laser or a chemical HF laser are evaluated. Several designs for the explosion chamber are briefly reviewed, including the wet wall chamber, dry wall chamber, and chamber with moving walls. Some results of analysis of a wet wall system have revealed the effect of wall diameter on tritium production. A laser thermonuclear electric power plant is proposed that has an electric efficiency comparable with that of thermal neutron atomic power plants, though the cost per installed kilowatt is still 2.0-2.5 times greater than that of the atomic plant. The proposed design makes use of laser heat to preheat the water.

P.T.H.

A79-35174 # Calculation of hysteresis losses in superconducting coils (K raschetu gisteresiznykh poter' v sverkhprovodiashchikh obmotkakh). V. B. Zenkevich and V. V. Zheltov. *Akademii Nauk SSSR, Izvestiia, Energetika i Transport*, Mar.-Apr. 1979, p. 70-79. 8 refs. In Russian.

Analytic expressions are obtained for calculating the losses in superconducting coils on the basis of the Bean-London model, where the critical current is assumed to be constant. A calculation method is then proposed which takes into account a simple dependence of the critical current on the local induction proposed by Kim et al. (1963). This latter method yields more accurate values for the threshold amplitude.

P.T.H.

A79-35176 # Optimization of radioisotope thermoelectric generators with gamma-radiation protection (Optimizatsionnyi raschet radioizotopnykh termoelektricheskikh generatorov s zashchitoy ot gamma-izlucheniia). E. P. Oganov, I. M. Makarevich, and G. V. Padarin. *Akademiia Nauk SSSR, Izvestiia, Energetika i Transport, Mar.-Apr. 1979*, p. 127-134. 7 refs. In Russian.

The paper describes a method of optimizing the design of radioisotope thermoelectric generators for a specific output electric power and voltage with constraints on the gamma-radiation dosage behind the protective shield and on the temperature levels in the two-cascade converter. Initial equations describing the thermal processes in the generator and the thermoelectric processes in the two-cascade converter and the radiation and physical processes in the radioisotope heat source and in the radiation shield are presented. An iterative method of solving the optimization problem on computer is proposed. P.T.H.

A79-35228 Energy policies in the context of global economics (Energiepolitik im weltwirtschaftlichen Zusammenhang). H. Michaelis. *Energiewirtschaftliche Tagesfragen*, vol. 29, Apr. 1979, p. 187-194. 16 refs. In German.

The current and future status of the world's energy potentials, as well as the principal options on energy policies are reviewed. The oil crisis of 1973 and its basic causes are examined, as are the medium-term/long-term prospects of oil reserves, and the ways leading to an adequate protection of oil energy investments. The possibilities of exploring alternative energies, such as nuclear, wind, and solar, are assessed. The importance of regarding the economics of energy in a global context is noted. A.A.

A79-35229 Aspects of the supply potential of the heat pump (Versorgungsseitige Gedanken zur Wärmepumpe). K.-H. Schwarze. *Energiewirtschaftliche Tagesfragen*, vol. 29, Apr. 1979, p. 201-203. In German.

Design and supply potential of the heat pumps are discussed. The operational differences between monovalent and bivalent electric heat pumps are considered, together with a review of their applications in residential and non-residential buildings. The pumps are compared with other electric heat systems, noting that the power demand for the first is about five times smaller than for the latter. Data on supply costs are presented. A.A.

A79-35343 # Investigation of extruded sintered-nickel-powder porous materials used as electrodes in fuel cells (Issledovaniye poristykh materialov iz spechennogo poroshka nikelia, poluchennykh mundshtunchnym pressovaniem, v kachestve elektrodov toplivnykh elementov). I. M. Fedorchenko, V. S. Pugin, P. A. Kornienko, D. A. Tkachenko, and L. G. Voloshina (Akademiia Nauk Ukrainskoi SSR, Institut Problem Materialovedeniia; Kievskii Politehnicheskii Institut, Kiev, Ukrainian SSR). *Poroshkovaia Metallurgiiia*, Mar. 1979, p. 38-40. In Russian.

A79-35377 # Zn/xCd/1-x/S solid solution solar cells (Solnechnye fotopreobrazovateli na osnove tverdykh rastvorov Zn/xCd/1-x/S). L. D. Budennaiia, P. P. Gorbik, V. N. Komashchenko, G. A. Fedorus, and E. V. Sharkina (Akademiia Nauk Ukrainskoi SSR, Institut Poluprovodnikov, Kiev, Ukrainian SSR). *Geliotekhnika*, no. 1, 1979, p. 3-5. In Russian.

Polycrystalline thin films of Zn(x)Cd(1-x)S were produced and used to prepare pCu2S-nZn(x)Cd(1-x)S heterojunction solar cells. The optimal concentration for construction of solar cells is found to be Zn(0.1-0.2)Cd(0.9-0.8)S. The photo-emf of the heterostructure of optimal composition attains a value of 0.8 V. The short-circuit current (and therefore the efficiency) of the heterostructure is limited mainly by a large series resistance. B.J.

A79-35378 # Temperature characteristics of high-voltage germanium photoconverters (Temperaturnye kharakteristiki vysokov-

vol'nykh fotogeneratorov iz germaniia). D. S. Strebkov, V. A. Tikhomirova, and G. B. Fedosova (Vsesoiuznyi Nauchno-Issledovatel'skii Institut Istochnikov Toka, Moscow, USSR). *Geliotekhnika*, no. 1, 1979, p. 6-9. In Russian.

The paper reports on the volt-ampere characteristics of high-voltage germanium photoconverters in the -50 to +100 C temperature range as well as on the temperature dependence of the principal parameters of the device. It is suggested that such photoconverters can be used as high-voltage dc converters, as IR detectors, and in conjunction with silicon photoconverters. B.J.

A79-35379 # Analysis of the series resistance of thin-film pCdTe-nCdS photoconverters (Analiz posledovatel'nogo soprotivleniia plenochnykh pCdTe-nCdS-fotopreobrazovatelei). S. A. Azimov, Sh. A. Mirsatgov, D. T. Rasulov, and N. Shakirov (Akademiia Nauk Uzbekskoi SSR, Fiziko-Tekhnicheskii Institut, Tashkent, Uzbek SSR). *Geliotekhnika*, no. 1, 1979, p. 10-12. 6 refs. In Russian.

A79-35380 # Spectral emissivity of porous graphite heated in air (Spektral'naia izluchatel'naia sposobnost' poristogo grafita, nagrevaemogo v atmosfere vozdukh). N. A. Rubtsov, A. G. Tarasov, and G. V. Miakin (Akademiia Nauk SSSR, Institut Teplofiziki, Novosibirsk, USSR). *Geliotekhnika*, no. 1, 1979, p. 13-16. In Russian.

An optical facility for measuring spectral emissivity is described. The system is applied to measuring the emissivity of PG-50 graphite heated in air, taking into account the character of the emitting surface and wavelength and temperature. An inverse relationship between wavelength and spectral emissivity is shown. B.J.

A79-35381 # Optimal geometrical properties of cavity-type solar collectors with selective absorption properties (Optimal'nye geometricheskie parametry polostnykh geliopriemnikov s selektivnymi svoistvami luchepogloshcheniia). R. A. Zakhidov, A. Abdurakhmanov, and Sh. I. Klychev (Akademiia Nauk Uzbekskoi SSR, Tsentral'noe Proektno-Konstruktorskoe i Tekhnologicheskoe Biuro Nauchnogo Priborostroeniia, Uzbek SSR). *Geliotekhnika*, no. 1, 1979, p. 17-20. In Russian.

A79-35382 # Combined radiant-flux controller for a high-temperature solar energy system (Kombinirovannyi reguliator luchistogo potoka vysokotemperaturnoi gelioustanovki). V. V. Afian and A. V. Vartanian. *Geliotekhnika*, no. 1, 1979, p. 21-24. In Russian.

The paper describes a radiant-flux controller for a high-temperature solar collector system with paraboloidal concentrator; block and kinematic diagrams are presented. The controller consists of two screening cylinders (external and internal) in simultaneous operation. The device controls two parameters: radiant flux density in the focus and collected power. An experimental controller has been tested. B.J.

A79-35383 # Accelerated testing of the optical radiation resistance of profiled polyethylene sleeves and sheets under natural climatic conditions (Uskorennoe issledovanie svetostoikosti profilirovannykh rukavov i listov v estestvennykh klimaticheskikh usloviakh). V. N. Volkov, Ia. T. Shermazanjan, N. V. Shilko, A. G. Sinabarimian, and T. A. Nersisian. *Geliotekhnika*, no. 1, 1979, p. 39-42. 8 refs. In Russian.

Profiled polyethylene sleeves and sheets were subjected to accelerated testing in a solar-radiation facility. Polyethylene stabilized with soot additive was found to have the highest radiation resistance; color-tinted polyethylene was found to have the least. It is recommended that the soot-stabilized variety be used outdoors while the color-tinted variety be used indoors (under conditions of scattered solar radiation). B.J.

A79-35384 # Investigation of the optical properties of transparent materials for solar energy applications (Issledovanie opticheskikh kharakteristik prozrachnykh geliotekhnicheskikh materialov). N. B. Rekant and S. A. Demidov (Gosudarstvennyi Nauchno-Issledovatel'skii Energeticheskii Institut, Moscow, USSR). *Geliotekhnika*, no. 1, 1979, p. 46-49. In Russian.

A simple method is developed for measuring the absorptivity and transmissivity of thin polymeric films at room temperature. The chief characteristic of the materials tested is their semitransparency (during interaction with thermal radiation) in a wide spectral range, from the UV to the far-IR. B.J.

A79-35385 # Analysis of the efficiency of a variable-band photoconverter (Analiz effektivnosti varizonnogo fotoelektricheskogo preobrazovatel'ia). L. I. Gromovoi, L. I. Tikhonov, and V. N. Diatlov. *Geliotekhnika*, no. 1, 1979, p. 57-62. 8 refs. In Russian.

The volt-ampere characteristics and the photocurrent under solar illumination of a variable-band semiconductor structure are calculated. Consideration is then given to the efficiency of a variable-band $\text{pAl(x)Ga(1-x)As-nGaAs}$ solar cell and the efficiency of this type of cell is compared to that of a homogeneous GaAs solar cell. Particular attention is given to the case when the variable-band region can be represented as a 'direct' semiconductor (i.e., x is not greater than 0.4). B.J.

A79-35461 The fusion hybrid. H. A. Bethe. *Physics Today*, vol. 32, May 1979, p. 44, 45, 48-51.

A fusion hybrid involves surrounding a fusion reactor with a blanket of uranium or thorium. Fast neutrons produced in the fusion reaction convert the thorium or uranium into fissile isotopes of uranium and plutonium, respectively; the fissile material then can be employed to fuel ordinary nuclear reactors. Hybrid fusion schemes could be made economical with less technological development than that required for commercially viable pure fusion reactors. In addition, the hybrid reactors will pose fewer security problems than the presently planned fast breeder reactors. J.M.B.

A79-35463 The effects of oil on marine life. E. W. Mertens (Chevron Research Co., Richmond, Calif.) and J. R. Gould (American Petroleum Institute, Washington, D.C.). *Erdöl und Kohle Erdgas Petrochemie vereinigt mit Brennstoff-Chemie*, vol. 32, Apr. 1979, p. 162-166. 29 refs. Research sponsored by the American Petroleum Institute.

The paper gives an overview of research being conducted by API on the effects of oil on marine life. Laboratory tests have been shown that marine organisms contaminated by various types of oils rapidly purge themselves once their exposure to such oils has been terminated. Preliminary studies on the effects of a crude oil on the four larval stages of the American lobster indicated that concentrations of 0.1 and 1.0 ppm crude oil did not diminish survival success of test organisms. The population levels, growth rate and reproductivity of marine organisms are not affected by low-level chronic exposure to oil. Moreover, offshore platforms provide a structure whereby a thriving, highly complex community of marine life can develop. P.T.H.

A79-35464 Solar energy and heat pumps - A possible substitute for fossil fuels for heating private households (Sonnenenergie und Wärmepumpe - Ein vollwertiger Ersatz für fossile Brennstoffe bei der Beheizung von Privathaushalten). H.-P. Schmiedel (Mobil Oil AG, Wedel, West Germany). *Erdöl und Kohle Erdgas Petrochemie vereinigt mit Brennstoff-Chemie*, vol. 32, Apr. 1979, p. 167-173. In German.

The possibilities for solar energy and heat pumps to be used under the climatic conditions of Germany are discussed. Solar collector construction principles are briefly reviewed. It is shown why in winter the efficiency of solar collection is least. The same holds for heat pumps, for which the efficiency decreases as the

temperature difference between heat taken in and released increases. These problems indicate that for all-year-round heating, fossil fuels will play a significant role in the future. P.T.H.

A79-35476 French solar policy - Its extent, its methods, its objectives (La politique solaire française - Son étendue, ses moyens, ses objectifs). C. Durand (Commissariat à l'Energie Solaire, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 153-157. In French.

A79-35477 Industrial applications of solar heat (Les applications de la chaleur solaire à l'industrie). F. Moisan (CNRS, Laboratoire d'Astronomie Spatiale, Marseille, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 161-165. In French.

Industrial processes requiring low- or medium-temperature heat are candidates for solar energy development in France. Food processing installations, textile factories, and chemical plants are among the industrial applications for low- and medium-temperature solar heat. Concentrating collectors capable of producing heat at temperatures approaching 350 C are currently under development. A regional survey of the energy requirements for agriculture and food processing installations in France is presented to suggest the extent of the market for low- and medium-temperature solar heat. J.M.B.

A79-35478 An oil company expresses interest in solar energy (Un pétrolier s'intéresse à l'énergie solaire). M. Walon (Total CFD, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 166-172. In French.

Solar heating, cooling and domestic hot water systems are discussed; attention is also given to a pilot program for a solar-heated greenhouse. The domestic hot water systems typically involve flat-plate collectors and have output temperatures of about 100 C. A domestic solar heating and air conditioning installation utilizing both passive and active systems, and a greenhouse heating plant based on 70 flat-plate collectors with a surface area of 140 sq m are described. J.M.B.

A79-35479 SOLPAC - A total design for energy conservation in housing (SOLPAC - Une conception d'ensemble pour l'habitat à économie d'énergie). P. Dubois (Compagnie Générale d'Electricité, Division Energie, Marcoussis, Essonne, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 173-178. In French.

Architectural design and an active solar energy system have been integrated in developing a domestic hot water and heating scheme for a single-family residence. Minimization of the external surfaces of the house (i.e., a design approaching the spherical), roof and wall insulation, and construction of a buffer zone facing the direction of maximum insolation are among the architectural elements incorporated in the energy-saving residence. Flat-plate collectors are adopted for the solar heating and hot water systems. Savings of 30 percent with respect to conventional schemes are expected for the residence. J.M.B.

A79-35480 Solar energy and decentralized electricity production - Low-power solar pumps and installations (Energie solaire et production décentralisée d'électricité - Pompes solaires et installations de faible puissance). M. G. Clénot (Société d'Etudes Thermiques et d'Energie Solaire, France) and J. Pheline (Commissariat à l'Energie Atomique, Paris, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 179-184. In French.

Skirting a detailed description of technologies for which ample documentation already exists, this article attempts to offer a glimpse of the practical potential, the advantages and disadvantages of the various main techniques for solar-radiation collection and conversion into electricity, accompanied by a projection of their medium-term economic prospects, on the basis of installations already implemented in France. (Author)

A79-35481 Solar power plants. I - Present programs and outlooks (Les centrales solaires de puissance. I - Projets actuels et perspectives). C. Etievant (CNRS, Paris, France) and F. Pharabod

(Electricité de France, Paris, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 185-200. In French.

The heliostat arrays, receivers, thermal storage systems and thermodynamic cycles of six solar power plants are described; the electric power stations are designed to produce from 500 to 10,000 kWe and will be in service by 1981. Particular attention is given to heliostat design, which requires high reflectivity maintainable over a period of years, resistance to deformation from winds, and high pointing precision. Selection of a thermal storage medium (e.g., molten salts and organic fluids), and the adoption of such systems as the closed or open Brayton cycle for thermodynamic conversion are also considered. J.M.B.

A79-35482 **Solar power plants. II - Economic aspects of solar power towers (Les centrales solaires de puissance. II - Les aspects économiques des centrales solaires à tour).** M. Clavier and C. Etievant (CNRS, Paris, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 200-208. 24 refs. In French.

Two critical factors affecting the economics of solar power towers are the investment required for the construction of the power station, and the cost and preparation of the site. Economic analyses are presented for 1- and 10-MW solar power towers; while the capital investment needed for such installations is large, the long-term savings can be great in comparison to nuclear and coal-fired plants, especially in tropical countries where the solar resource is maximal. J.M.B.

A79-35483 **Solar power towers (Les centrales solaires à tour).** M. Bignon (CETHEL, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 209-217. In French.

Components of solar power towers include a heliostat array, a central receiver, a thermodynamic conversion system, and a thermal storage unit. A 1-MW solar power tower prototype which has 17,500 sq m of mirror surface and a tower 90 m in elevation is currently under development in France. A joint European project to develop another 1-MW solar power tower is also mentioned. J.M.B.

A79-35484 **Medium-power /100 to 1000 kWe/ heat and electricity production from solar sources (La production de chaleur et d'électricité d'origine solaire à moyenne puissance 100 à 1000 kWe).** J. L. Boy-Marcotte and R. Grossin (Société Bertin et Cie., Plaisir, Yvelines, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 218-223. 7 refs. In French.

The collectors, thermal storage systems, and turbines employed in medium-power (100 to 1000 kWe) solar electric power plants under development in France are described. The medium-power solar power plants have applications to street lighting, domestic electricity requirements, refrigeration, and heat for food processing plants. Cylindrical parabolic collector mirrors, segmented collector mirrors, point-focusing collectors, and organic-fluid turbines are among the technological innovations which may make the solar power plants feasible. J.M.B.

A79-35485 **Organic synthesis fluids for solar energy systems (Les fluides organiques de synthèse dans l'énergie solaire).** A. Neithardt (Rhône-Poulenc, Paris, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 224-227. In French.

This article gives a progress report on tests and projects of national and international scope currently being implemented in France which involve the use of hydrogenated terphenyl as a heat-carrying fluid. Other projects are on the drawing-board, but their description would be premature at this stage. (Author)

A79-35486 **Photovoltaic cells and their future (Les filières de photopiles et leur avenir).** M. Rodot and A. Dupas (CNRS, Paris, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 228-235. In French.

Production of silicon, gallium arsenide and cadmium sulfide photovoltaic cells is discussed, with particular attention given to

techniques which permit lowering the cost of manufacturing. The cost of connective elements, storage batteries, and converters for the photovoltaic arrays is also taken into consideration. In addition, technological developments in contact and junction formation are mentioned. J.M.B.

A79-35487 **Solar cells from inexpensive silicon ribbons - State of the art and trends (Cellules solaires à partir de rubans de silicium à faible prix de revient - Etat des techniques et évolution).** A. I. Mlavsky (Mobil Tyco Solar Energy Corp., Waltham, Mass.). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 238-245. 9 refs. In French. (Translation).

A process, initially intended for the production of sapphire crystals formed directly from the molten state, offers a technological foundation for the production of cost-effective silicon solar cells. This article describes the method, applied to the production of silicon ribbon-based solar cells, from the standpoint of economics and the technological state of the art. (Author)

A79-35488 **The development of solar power satellites (La mise au point de satellites à énergie solaire).** P. E. Glaser (Arthur D. Little, Inc., Cambridge, Mass.). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 246-266. In French. (Translation).

A 5-GW solar power satellite employing silicon or gallium arsenide photovoltaic cells is being considered for development. Power transmission schemes and the transport system needed to orbit the materials and personnel for the solar power satellite are discussed. Cost projections, technological problems associated with receiving antennas, and possible environmental effects of the solar power satellite also receive attention. J.M.B.

A79-35489 **Bioconversion - Energy and agriculture (Bioconversion - Energie et agriculture).** P.-A. Jayet (Institut National de la Recherche Agronomique, Paris, France). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 267-278. In French.

Incineration, gasification, anaerobic digestion, pyrolysis and hydrolysis are among the means of converting biomass into energy. A total of 65 million tons of biomass from agriculture and forestry is available for energy conversion in France yearly; straw represents a particularly attractive biomass resource because of ease of processing and transport. Boilers operating with various types of processed straw are in service in France and Denmark. Pyrolysis processes employing wood or municipal solid waste are also mentioned. J.M.B.

A79-35490 **Solar options in central Europe - A synthesis of solar possibilities in technological terms according to present-day /1978/ criteria (Options solaires en Europe centrale - Synthèse des possibilités solaires au plan technologique selon les critères actuels /1978/).** C. R. Bell (International Institute for Applied Systems Analysis, Laxenburg, Austria). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 284-292. In French. (Translation).

A survey of insolation and cloud cover at 40 and 50 deg N in central Europe indicates that low- and medium-temperature solar energy systems are feasible. In addition, photovoltaic arrays for the production of electricity or, eventually, hydrogen or synthetic combustibles, may also be viable in the central European region. Thermal storage facilities, retrofitting solar heating systems to existing structures, and the development of passive solar systems are also considered. J.M.B.

A79-35491 **Solar energy as the basis of an energetic system (L'énergie solaire base d'un système énergétique).** J. M. Weingart (California, University, Berkeley, Calif.). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 293-302. 17 refs. In French. (Translation). Research supported by the Ford Foundation, International Institute for Applied Systems Analysis, Electric Power Research Institute, and University of California.

Options for the replacement of fossil fuels by other energy sources include the production of industrial process heat, hydrogen and electricity from solar energy, biomass conversion, ocean thermal

energy conversion, solar power satellites, and fusion reactors. A comprehensive development program for solar energy might include local solar heating and hot water systems, solar power plants for the production of electricity, and solar energy production of hydrogen and liquid fuels. Consequences of large-scale solar energy development for the environment are assessed. J.M.B.

A79-35492 A completely solar power supply for France (Un approvisionnement tout solaire pour la France). M. Grenon and F. Katsonis (International Institute for Applied Systems Analysis, Laxenburg, Austria). *Revue de l'Energie*, vol. 30, Mar. 1979, p. 303-310. In French.

A completely solar power supply for France would include electric generating systems (solar power towers and systems based on photovoltaic cells), solar-powered electrolysis to produce hydrogen, low-temperature heat and hot water production based on solar collectors, and industrial process steam derived from solar concentrators. In this scenario, solar power towers would provide 30.8% of the French national energy requirement, photovoltaic systems 20.3% of the requirement, and hydrogen produced by photovoltaic arrays, 21.5%. The remainder of the energy requirement would be met by hydroelectric and gas turbine installations. J.M.B.

A79-35525 # Use of fluidized media in thermal power systems (Problema ispol'zovaniia psevdoozhizhennykh sred v teplo-energetike). N. I. Syromiatnikov, V. N. Korolev, and B. G. Sapozhnikov (Ural'skii Politekhnikeskii Institut, Sverdlovsk, USSR). *Energetika*, vol. 22, Feb. 1979, p. 41-50. 29 refs. In Russian.

The paper discusses some results of studies of the flow past heat transfer surfaces in the form of bundles of cylinders in fluidized media. Visual observations and X-ray photographs were used. The effect of the geometry of the bundles on the flow pattern and heat transfer was studied. P.T.H.

A79-35601 # Some aspects of variable operating regimes of an MHD generator (Nekotoryye voprosy peremennykh rezhimov raboty MGD-generatora). V. V. Belikov, V. V. Breev, A. V. Gubarev, and A. V. Zotov. *Magnitnaia Gidrodinamika*, Jan.-Mar. 1979, p. 89-96. 5 refs. In Russian.

Some of the variable operating regimes of MHD generators of independent, parallel, and series excitation are characterized. For parallel and series excitations, the current-voltage characteristics are given, and the limiting values of certain characteristics are computed. The variation of parameters along the length of the duct is established for normal and anomalous duct current regimes as the counterpressure in a supersonic generator increases. A plot of the transient regimes of a generator with series connection of the magnetic coil is constructed. P.T.H.

A79-35656 Effect of friction on motion of a piston driven by combustion products. V. A. Poselevich, N. N. Piliugin, and S. Iu. Cherniavskii. (PMTF - Zhurnal Prikladnoi Mekhaniki i Tekhnicheskoi Fiziki, Sept.-Oct. 1978, p. 73-80.) *Journal of Applied Mechanics and Technical Physics*, vol. 19, no. 5, Mar. 1979, p. 634-639. 14 refs. Translation.

In recent years, the two-stage light gas ballistic apparatus with deformable plastic pistons has become widely used in experimental aerodynamics. The existing methods of calculating such devices either completely neglect friction of the piston against the channel walls, or use a schematization of the frictional forces which does not have a satisfactory physical basis. In a number of studies, the friction force was considered constant and its value was specified not from physical considerations, but to produce the best agreement between calculated and experimental values of object velocity or driving gas pressure. Since friction is such a significant factor, its proper consideration in calculating piston motion parameters requires special study. In this connection, it is useful to consider the operation of only the first stage of the ballistic apparatus, which sets the piston in motion. The present analysis deals with the internal ballistics of a one-stage powder-driven apparatus in which a piston

made of polymer material performs a friction motion. The friction model is constructed on the basis of a series of experiments on the slow forcing of polymer specimens compressed in the longitudinal direction through a steel channel. (Author)

A79-35746 The fabrication of Schottky-barrier solar cells by electroless nickel plating. J. T. Lue (National Tsing Hua University Hsinchu, Nationalist China). *Applied Physics Letters*, vol. 34, May 15, 1979, p. 688-690. 16 refs. Research supported by the National Science Council of Nationalist China.

The application of electroless nickel plating to the fabrication of Schottky barrier contacts for solar cells is reported. A borohydride-based plating bath is employed for the formation of a metallized layer for p-type silicon. The C-V characteristics of the electroless plated diode reveal the barrier height of a plated diode (0.83 V) to be 100 mV higher than that of a vacuum deposited diode. The phosphorus content of the deposit is shown to increase from 7% as bath pH decreases from 9.5. I-V characteristics of plated and evaporated samples show higher leakage current and poorer front-to-back contact leakage in the plated sample. The electroless plating method is considered practical for the fabrication of solar cells because of the lower cost, good surface adhesion, higher barrier potential height and higher light absorption of plated diodes compared to vacuum evaporated devices. A.L.W.

A79-35749 Thin-film GaAs solar cells with grain-boundary edge passivation. S. K. Ghandhi, J. M. Borrego, D. Reep, Y.-S. Hsu, and K. P. Pande (Rensselaer Polytechnic Institute, Troy, N.Y.). *Applied Physics Letters*, vol. 34, May 15, 1979, p. 699-701. 9 refs. Contract No. EG-77-S-01-4116.

Solar cells built on polycrystalline gallium arsenide usually have very leaky reverse characteristics and low open circuit voltage. Both these problems arise from the effect of the Schottky diode made on the grain boundary, which shunts the active Schottky solar cell and deteriorates its performance characteristics. Selective anodization techniques have been used to provide an insulating barrier over the grain boundary in order to passivate it. Leakage current reduction of five to six decades has been achieved by this method. The present paper describes the electrical and photovoltaic characteristics of devices made by this technique. A simulated AM1 conversion efficiency of 5.45% on thin-film (8.6 micron) polycrystalline GaAs cells with no antireflection coating, fabricated on molybdenum substrates by the simultaneous pyrolysis of trimethylgallium and arsine in hydrogen is reported for the first time. (Author)

A79-35799 Coal gasification for electric utilities. R. Whitaker, N. Holt, and M. Gluckman (Electric Power Research Institute, Palo Alto, Calif.). *ERPI Journal*, vol. 4, Apr. 1979, p. 6-13.

The article investigates approaches, problems and applications involved in coal gasification processes. It is suggested that coal should be gasified for generating electricity, rather than burned directly, with the resulting air pollution. Three different approaches are presented: the fixed bed gasifier and its derivative the slagging gasifier, the fluidized bed gasifier, and the entrained gasification system. Other topics covered are slurry handling and products of gasification. Separate sections explain gasification chemistry and integrating gasification and generation. M.E.P.

A79-35800 Eighty atmospheres in reserve. N. Lihach, T. Schneider, W. Stevens, and A. Ferreiro (Electric Power Research Institute, Palo Alto, Calif.). *ERPI Journal*, vol. 4, Apr. 1979, p. 14-18.

The article explores the storing of compressed air in underground caverns for use as a peaking power source. Such a system is already in use in Huntorf, West Germany, and is being studied by American utilities. Underground caverns such as salt domes and aquifers as well as mined caverns would be less costly than above-ground pressure vessels. The unusual problems encountered in implementing such a system, such as salt caused turbine blade

corrosion, are analyzed. Furthermore, when the air is released to drive the generators it must still be heated to make it more effective. Efficient ways of doing this without the use of fossil fuels, such as turbine heat recuperation or compression heat recovery, and other possibilities are also discussed. M.E.P.

A79-35820 Temperature dependence of the optical properties of silicon. H. A. Weakliem and D. Redfield (RCA Laboratories, Princeton, N.J.). *Journal of Applied Physics*, vol. 50, Mar. 1979, p. 1491-1493, 10 refs.

The spectral dependence of the absorption coefficient of silicon for photon energies up to 2.7 eV was determined for several temperatures in the range 298-473 K. The effect of a temperature increase appears as a red shift of the absorption spectrum. The magnitude of the shift is larger than that of the fundamental energy gap, increases with increasing photon energy in the range 1.1-1.7 eV, and is constant for energies greater than 1.7 eV. A phenomenological expression deduced by analysis of the data may be used to calculate $\alpha(E)$ at elevated temperature, given $\alpha(E)$ at room temperature. The reflectance was also measured at 299, 413, and 516 K in the photon energy range 2.5-3.8 eV. (Author)

A79-35846 Preliminary selection of anchor systems for ocean thermal energy conversion. J. M. Atturio, P. J. Valent, and R. J. Taylor (U.S. Navy, Civil Engineering Laboratory, Port Hueneme, Calif.). *Ocean Engineering*, vol. 6, no. 1-2, 1979, p. 139-167, 9 refs. ERDA-sponsored research.

Anchor designs for ocean thermal energy conversion (OTEC) plants located in the deep ocean or in the Gulf Stream region are under investigation. A deadweight anchor with cutting edges appears to offer an effective and economical means for stabilizing deep-ocean OTEC plants; pile anchors would require a significant amount of seafloor construction. Pile anchor systems, however, are competitive with deadweight anchors for unconsolidated seafloors in the Gulf Stream region. Controlled buoyancy systems for handling and lowering the deadweight anchors are among the technological requirements of the OTEC plant anchoring schemes. J.M.B.

A79-36049 High-temperature nuclear heat source for hydrogen production. R. N. Quade (General Atomic Co., San Diego, Calif.) and L. Meyer (General Atomic Europe, Zurich, Switzerland). *International Journal of Hydrogen Energy*, vol. 4, no. 2, 1979, p. 101-110, 6 refs.

The combination of nuclear breeder reactors and thermal converters can efficiently utilize uranium and thorium reserves and is a worldwide energy source which is potentially 20 times greater than coal. The very high temperature reactor (VHTR), a thermal converter, can be coupled to open and closed cycle processes to produce hydrogen in large quantities. Current work in the U.S. is focused on the design of a VHTR of about 850 MW(t). The thermal rating and the design are similar to those of the steam cycle Fort St. Vrain (FSV) reactor built in Colorado, U.S., but an intermediate helium circuit and a core outlet temperature of 925-950 C are used. Hydrogen production using this reactor would be approximately 10 kg/sec with a carbon-based process or 3 kg/sec with a closed-loop thermochemical process. (Author)

A79-36144 Solar energy conversion: Solid-state physics aspects. Edited by B. O. Seraphin (Arizona, University, Tucson, Ariz.). Berlin and New York, Springer-Verlag (Topics in Applied Physics. Volume 31), 1979. 348 p. \$53.90.

Solid-state aspects of solar energy conversion systems are discussed, with attention given to spectrally selective surfaces, carrier lifetimes in silicon, solar photoelectrolysis with semiconductor electrodes, heterojunction phenomena and interfacial defects in photovoltaic converters, and the Cu₂S/CdS cell. The reviews include discussions of chemical vapor deposition of silicon, black-chrome

electroplated coatings and semiconductor cermet films for photo-thermal converters, highly doped, highly conductive semiconductors for electrochemical solar cells, and the photoconductive decay technique for determining the carrier lifetime of a semiconductor crystal. J.M.B.

A79-36145 Spectrally selective surfaces and their impact on photothermal solar energy conversion. B. O. Seraphin (Arizona, University, Tucson, Ariz.). In: *Solar energy conversion: Solid-state physics aspects*. Berlin and New York, Springer-Verlag, 1979, p. 5-55, 125 refs.

Solar energy systems require materials that are both good absorbers and poor emitters; such a seemingly contradictory requirement can be met by spectrally selective surfaces. High-absorptance amorphous silicon produced by chemical vapor deposition (CVD) and CVD refractory-metal reflectors fabricated by simple techniques are among the most promising developments in the field of spectrally selective surfaces. Continuous flow-through CVD could provide an economical means for large-scale deposition of photothermal converters of high-temperature durability. J.M.B.

A79-36146 Spectral selectivity of composite materials. A. J. Sievers (Cornell University, Ithaca, N.Y.). In: *Solar energy conversion: Solid-state physics aspects*. Berlin and New York, Springer-Verlag, 1979, p. 57-114, 122 refs. NSF Grant No. DMR-76-81083; Contract No. EG-77-S-03-1456.

The thermal emissivity of metals is investigated, and a criterion for assessing the usefulness of spectrally selective composite materials for solar energy collectors is derived. Surface impedance, the classical skin-effect limit, surface scattering and electron-photon scattering are taken into consideration in studying the emissivity of smooth metal substrates. Composite dielectric functions are calculated for Drude and transition metals; the optical behavior of metal particles on a copper substrate is simulated by computer techniques. The application of black-chrome electroplated coatings and semiconductor cermet films to photothermal converters is discussed. J.M.B.

A79-36147 Solar photoelectrolysis with semiconductor electrodes. H. Gerischer (Max-Planck-Gesellschaft zur Förderung der Wissenschaften, Fritz-Haber-Institut, Berlin, West Germany). In: *Solar energy conversion: Solid-state physics aspects*. Berlin and New York, Springer-Verlag, 1979, p. 115-172, 118 refs.

A solar photoelectrolytic cell with semiconductor electrodes as energy converters exploits photoredox reactions and has the energy conversion efficiency of the photosynthetic process. In the photoelectrolytic cell, a counterelectrode must be in electronic contact with the semiconductor to pick up one of the mobile charge carriers produced in the semiconductor by light absorption. In addition, a space-charge layer is required in the semiconductor beneath the interface to render the charge separation efficient. The chief problem of photoelectrolytic cells based on semiconductors is the susceptibility of the semiconductors to photodecomposition. Highly doped, highly conductive semiconductors applicable to electrochemical solar cells are described, and the efficiency of photoelectrochemical regenerative and storage cells is discussed. J.M.B.

A79-36148 Carrier lifetime in silicon and its impact on solar cell characteristics. K. Graff and H. Fischer (Telefunken AG, Heilbronn, West Germany). In: *Solar energy conversion: Solid-state physics aspects*. Berlin and New York, Springer-Verlag, 1979, p. 173-211, 49 refs.

The application of experimental results on carrier lifetime to solar cell design is discussed, with emphasis on p-type silicon. The carrier lifetime assessments are based not only on studies of the as-grown crystal, but also on investigations of the crystal following various temperature-annealing processes. Methods for determining the carrier lifetime in a semiconductor crystal include the photoconductive decay technique, the surface photovoltage technique, and measurements which apply the spectral response of solar cells. It is

shown that longitudinal as well as radial profiles of carrier lifetime in as-grown crystals are needed to characterize solar cells adequately.

J.M.B.

A79-36150 Heterojunction phenomena and interfacial defects in photovoltaic converters. A. L. Fahrenbruch and J. Aranovich (Stanford University, Stanford, Calif.). In: *Solar energy conversion: Solid-state physics aspects*. Berlin and New York, Springer-Verlag, 1979, p. 257-326. 173 refs. Research supported by the Department of Energy and U.S. Air Force.

Descriptive models for heterojunction transport in photovoltaic converters are discussed, with attention given to both energy band profiles and the spatial and energy distributions of centers involved in recombination, tunneling and charge storage. In heterojunction, metal-semiconductor and metal-insulator-semiconductor structures, properties within the depletion layer generally determine electrical transport; more specifically, transport can be said to be dominated in most cases by a thin region including the interface. Thus metallurgical and defect electronic properties of the interfacial zone must be included in a characterization of heterojunction devices used in solar energy conversion systems.

J.M.B.

A79-36201 The problem of carbon dioxide. F. Niehaus. *International Atomic Energy Agency Bulletin*, vol. 21, Feb. 1979, p. 2-10. 12 refs.

The problem of the increasing concentration of carbon dioxide in the atmosphere is examined in relation to the impact of energy conversion alternatives on CO₂ levels. Atmospheric carbon dioxide concentration, which has increased by more than 10% since the beginning of industrialization, presents a risk mainly due to its effect on the atmospheric radiation balance. A doubling of CO₂ concentration had been calculated to lead to a temperature increase of 2 to 3 C in the lower troposphere. A model based on a loop-structure carbon cycle is used to show that a world energy economy based entirely on fossil fuels at the level of 50 TW would cause a fivefold increase in atmospheric carbon dioxide and a global temperature increase of 5 C by the year 2100, whereas an economy based on solar and nuclear energy at the same level would lead to a maximum temperature change of 0.6 C. Such temperature changes could decrease world food production, raise sea level and result in climatic changes.

A.L.W.

A79-36241 The role of the interfacial layer in Schottky barrier solar cells. N. K. Swami, S. Srivastava, and H. M. Ghule (Birla Institute of Technology and Science, Pilani, India). *Journal of Physics D - Applied Physics*, vol. 12, May 14, 1979, p. 765-771. 8 refs. Research supported by the University Grants Commission.

The interfacial layer in a Schottky barrier solar cell plays an important role in reducing the dark current, which in turn improves the open-circuit voltage and the efficiency of the solar cell. From the transmission of electrons and holes across the interfacial layer we have analysed the current mechanism in a Schottky barrier solar cell under two approximations. It is shown that the efficiency of the cell increases at first with the interfacial layer thickness δ , and after acquiring a maximum value falls with a further increase of δ . The variation with δ of the short-circuit current, the open-circuit voltage and the fill factor are also discussed.

(Author)

A79-36380 Manufacturers developing fuel-efficient engines. J. Mayfield. *Aviation Week and Space Technology*, vol. 110, May 28, 1979, p. 46, 47, 49 (3 ff.).

The paper presents an analysis for both the General Electric and Pratt & Whitney fuel-efficient turboprops developed under NASA's Energy Efficient Engine (E3) project. General Electric engine will produce 36,000 lb of thrust and have a bypass ratio of 6.8 during maximum climb power operation. Specific fuel consumption (SFC) of 0.572 is predicted. Pratt & Whitney turboprop will produce 41,000 lb of thrust on takeoff with a bypass ratio of 6.55. Its thrust SFC is

predicted as 0.576. The engines use such advanced technologies as active clearance control, single-crystal turbine blades and vanes, new power metallurgy alloys, a 23:1 compressor, new combustor designs and digital electronic engine control systems, and may evolve into prototypes for the commercial transport powerplants of the 1990s.

V.T.

A79-36411 Stability properties of an anisotropic guiding center plasma and relation with the Suydam function. J. Y. Choe (New York University, New York, N.Y.) and R. C. Davidson. *Physics of Fluids*, vol. 22, May 1979, p. 882-888. 7 refs. Research supported by the U.S. Department of Energy.

The paper examines the effect of pressure anisotropy on the equilibrium and stability properties of an unstable guiding center plasma, and investigates the dependence of associated stability properties on the Suydam function S. A detailed parameter study of equilibrium and stability properties is presented. The dependence of stability properties on the Suydam function S is assessed by correlating maximum growth rates with the magnitude of S, and by examining the ratio of consecutive eigenvalues for each set of parameters. Numerical analysis shows that, even though the Suydam function occurs naturally in studies of marginal stability, the maximum growth rate (except for a narrow range of the anisotropy parameter α) is a monotonically decreasing function of the absolute value of S.

S.D.

A79-36432 Aerosol and ice nuclei measurements in the plume of the Homer City, Pa., power plant. R. F. Pueschel, R. C. Schnell, H. K. Weickmann, and D. L. Wellman (NOAA, Atmospheric Physics and Chemistry Laboratory, Boulder, Colo.). *Geophysical Research Letters*, vol. 6, May 1979, p. 371-374. U.S. Environmental Protection Agency Contract No. IAG-D5-0693.

A79-36505 # The effectiveness of multi-date, multi-scale aerial remote sensing imagery for monitoring coal mining operations and reclamation efforts in Alberta. D. B. Patterson and K. M. Campbell (Department of the Environment, Environmental Coordination Services, Edmonton, Alberta, Canada). In: *Canadian Symposium on Remote Sensing*, 5th, Victoria, British Columbia, Canada, August 28-31, 1978, Proceedings. Ottawa, Canadian Aeronautics and Space Institute, 1979, p. 165-173. 10 refs.

A79-36548 # Commercial potential of the Space Shuttle. G. W. Keyes (Boeing Aerospace Co., Seattle, Wash.). *American Astronautical Society, Goddard Memorial Symposium*, Washington, D.C., Mar. 28-30, 1979, Paper 79-058. 10 p.

Benefits of major investment by private industry in government space programs are presented. The U.S. space program is approaching a transition to the Space Shuttle which will create new opportunities in telecommunications, earth observation, energy, and materials processing. Expanded space telecommunications will create a large market in transmission of subsidiary communications such as electronic mail; the remote sensing Landsat system data could be used for weather and crop forecasting; and solar power satellite technology could be commercialized. Private industry can offer large capital investment and marketing capability exemplified by worldwide preeminence of the U.S. aerospace industry. Increased innovative development of space applications caused by participation of large numbers of individuals, reduced federal funding, and revenue returned to government are some of the possible benefits of private industry participation. Investigations showed that private industry shuttle operation can be profitable but significant questions regarding technical and financial details still exist.

A.T.

A79-36610 Measurement of minority carrier lifetime in solar cells from photo-induced open-circuit voltage decay. J. E. Mahan (Solar Power Corp., Woburn, Mass.), T. W. Ekstedt (Hewlett-Packard Laboratories, Palo Alto, Calif.), R. I. Frank (Microwave

Associates, Burlington, Mass.), and R. Kaplow (MIT, Cambridge, Mass.). *IEEE Transactions on Electron Devices*, vol. ED-26, May 1979, p. 733-739. 15 refs. Research sponsored by the National Patent Development Corp.

An experimental technique is presented for determining the excess minority carrier lifetime within the base region of p-n junction solar cells. The procedure is to forward-bias the solar cell with a flash from a stroboscope and then to monitor the decay of the open-circuit voltage. Results are given for conventional horizontal-junction devices, as well as for vertical single- and multijunction solar cells. Lifetimes obtained with this technique are compared with those obtained from a method based on open-circuit voltage decay following the abrupt termination of a forward current, and with results obtained from a traveling light spot measurement of base minority carrier diffusion length in vertical-junction solar cells, from which the lifetime can be inferred. It is found that the forward current method does not yield a reliable lifetime estimate. (Author)

A79-36627 Solar energy use through biology - Past, present and future. D. O. Hall (King's College, London, England). *Solar Energy*, vol. 22, no. 4, 1979, p. 307-328. 147 refs. Research sponsored by the United Nations. UN Project FP-1303-1321.

Recent literature on photosynthesis is reviewed with attention given to principles, efficiency, and applications. This is then discussed with reference to the development of photobiological energy conversion systems. Consideration is given to the application of photosynthesis to H₂ production, H₂O₂ production, carbon reduction, etc. B.J.

A79-36628 Health and safety hazards associated with solar concentration systems. L. L. Young, III (Sandia Laboratories, Albuquerque, N. Mex.). *Solar Energy*, vol. 22, no. 4, 1979, p. 329-333. 8 refs.

Health hazards associated with solar concentration systems are reviewed with particular emphasis placed on hazards to the eye. A methodology for computing eye hazards associated with solar collector and receiver systems is developed; threshold values are derived and multiple beam exposure parameters. B.J.

A79-36629 Integration of evacuated tubular solar collectors with lithium bromide absorption cooling systems. D. S. Ward, W. S. Duff, J. C. Ward, and G. O. G. Lof (Colorado State University, Fort Collins, Colo.). *Solar Energy*, vol. 22, no. 4, 1979, p. 335-341. Research supported by the U.S. Department of Energy.

By surrounding the absorber-heat exchanger component of a solar collector with a glass-enclosed evacuated space and by providing the absorber with a selective surface, solar collectors can operate at efficiencies exceeding 50 per cent under conditions of $\Delta T/H \text{ sub } T = 5 \text{ deg C sq m/kW}$ ($\Delta T = \text{collector fluid inlet temperature minus ambient temperature}$, $H \text{ sub } T = \text{incident solar radiation on a tilted surface}$). The high performance of these evacuated tubular collectors thus provides the required high temperature inputs (70-88 C) of lithium bromide absorption cooling units, while maintaining high collector efficiency. This paper deals with the performance and analysis of two types of evacuated tubular solar collectors integrated with the two distinct solar heating and cooling systems installed on CSU Solar Houses I and III. (Author)

A79-36630 Theoretical considerations in the use of small passive-solar test-boxes to model the thermal performance of passively solar-heated building designs. D. P. Grimmer (California, University, Los Alamos, N. Mex.). *Solar Energy*, vol. 22, no. 4, 1979, p. 343-350. 7 refs. Research sponsored by the U.S. Department of Energy.

A79-36631 Initial experimental tests on the use of small passive-solar test-boxes to model the thermal performance of passively solar-heated building designs. D. P. Grimmer, R. D. McFarland, and J. D. Balcomb (California, University, Los Alamos, N. Mex.). *Solar Energy*, vol. 22, no. 4, 1979, p. 351-354. 12 refs. Research sponsored by the U.S. Department of Energy.

A79-36632 Sizing phase-change energy storage units for air-based solar heating systems. J. J. Jurinak and S. I. Abdel-Khalik (Wisconsin, University, Madison, Wis.). *Solar Energy*, vol. 22, no. 4, 1979, p. 355-359. 5 refs. Contract No. E(11-1)-2588.

A simple method for sizing phase-change energy storage (PCES) units for air-based solar heating systems is presented. An effective heat capacity for the phase change unit is obtained as a function of its mass, latent heat, specific heat, and melting temperature. The effective heat capacity can then be used, along with any convenient design method for systems with sensible heat stores, such as the f-chart method, to estimate the thermal performance of the system utilizing PCES. (Author)

A79-36633 Extension of the Hottel-Whillier model to the analysis of combined photovoltaic/thermal flat plate collectors. L. W. Florschuetz (Arizona State University, Tempe, Ariz.). *Solar Energy*, vol. 22, no. 4, 1979, p. 361-366. 12 refs. Contract No. E(11-1)-2748.

The well known Hottel-Whillier model for thermal analysis of flat plate collectors is extended to the analysis of combined photovoltaic/thermal collectors in a manner, such that, with simple modification of the conventional parameters of the original model, all of the existing relations and supporting information available in the literature still apply. Beyond the basic assumptions of the original model, it is only necessary to assume that the local electrical conversion efficiency of the solar cell array (absorber) is a linear decreasing function of the local absorber temperature over its operating temperature range. Based on the extended model, examples of both thermal and electrical performance of a combined collector as a function of collector design parameters are presented and discussed. (Author)

A79-36634 Practical design considerations for CPC solar collectors. A. Rabl (Argonne National Laboratory, Argonne, Ill.), N. B. Goodman, and R. Winston (Chicago, University, Chicago, Ill.). *Solar Energy*, vol. 22, no. 4, 1979, p. 373-381. 25 refs. ERDA-supported research.

Several practical problems are addressed which arise in the design of solar collectors with compound parabolic concentrators (CPC's). They deal with the selection of a receiver type, the optimum method for introducing a gap between receiver and reflector to minimize optical and thermal losses, and the effect of a glass envelope around the receiver. This paper also deals with the effect of mirror errors and receiver misalignment, and the effect of the temperature difference between fluid and absorber plate. The merits of a CPC as a second stage concentrator are analyzed. (Author)

A79-36635 Integrated tandem solar cells. M. P. Vecchi (Instituto Venezolano de Investigaciones Cientificas, Caracas, Venezuela). *Solar Energy*, vol. 22, no. 4, 1979, p. 383-388. 7 refs.

The performance of integrated tandem solar cell (ITSC) devices made from pn homojunctions has been investigated. The intrinsic electrical interconnection present in an ITSC device places important restrictions on the choice of the energy gaps of the semiconductors to be used. Total conversion efficiencies are calculated and they are compared both with single solar cells and with independent tandem solar cell systems. It is concluded that ITSC devices are attractive solar energy converters provided that proper care is taken in the choice of materials used. (Author)

A79-36636 * Low-cost encapsulation materials for terrestrial solar cell modules. E. F. Cuddihy (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.), B. Baum, and P. Willis (Springborn Laboratories, Inc., Enfield, Conn.). *Solar Energy*, vol. 22, no. 4, 1979, p. 389-396. 8 refs.

The paper presents the findings of material surveys intended to identify low cost materials which could be functional as encapsulants (by 1986) for terrestrial solar cell modules. Economic analyses have indicated that in order to meet the low cost goal of \$2.70 per sq m, some or all of the following material technologies must be developed or advanced: (1) UV screening outer covers; (2) elastomeric acrylics; (3) weatherproofing and waterproofing of structural wood and paper

products; (4) transparent UV stabilizers for the UV-sensitive transparent pottants; and (5) cost-effective utilization of silicone and fluorocarbon materials. B.J.

A79-36637 **Concentrator cost bound for high-efficiency photovoltaic power production.** D. Faïman (Negev, University, Sede Boqer and Beersheba, Israel). *Solar Energy*, vol. 22, no. 4, 1979, p. 397, 398. 5 refs.

A79-36638 * **Optimization of tapered busses for solar cell contacts.** G. A. Landis (Spire Corp., Bedford, Mass.). *Solar Energy*, vol. 22, no. 4, 1979, p. 401, 402. 6 refs. Contracts No. JPL-954786; No. NAS7-100.

Some fraction of the power produced by a solar cell is necessarily lost by series resistance associated with the metallized contact grid and by shadowing of cell active area by the grid. There are several approaches to reducing these losses, such as choosing a more efficient pattern, optimizing line spacing, and using tapered busses. The present paper analyzes tapered lines and derives from this analysis a theoretical lower bound to metallization power loss, independent of pattern chosen. B.J.

A79-36678 **An analysis of the dependence of thermal transport parameters on organic content for Green River oil shales.** Y. Wang, K. Rajeshwar, and J. DuBow (Colorado State University, Fort Collins, Colo.). *Journal of Applied Physics*, vol. 50, Apr. 1979, p. 2776-2781. 19 refs. NSF Grant No. AER-75-18650.

An analysis of the trends in the variation of the thermal transport parameters with organic content (taking thermal diffusivity as an example) is presented for oil shales of the Green River formation. The Cheng-Vachon model (1969) gives good agreement with experimental data, for oil shales of medium grade (100-250 l/ton) and for heat flowing in directions perpendicular to the orientation of the shale bedding planes. The degree of anisotropy experimentally observed for thermal conductivity and thermal diffusivity for these materials is much less than that predicted by theory. The marked discrepancy between the experimental data and the trends predicted by theory for heat flow in directions parallel to the shale stratigraphic planes is explained in terms of departure from a strict parallel configuration and an effective lower value for the thermal diffusivity of the mineral phase. Good agreement with experimental data is shown by the geometric mean model and Maxwell's equation for the parallel case. (Author)

A79-36680 **The operation of the semiconductor-insulator-semiconductor solar cell - Experiment.** J. Shewchun, D. Burk (Brown University, Providence, R. I.), J. Dubow, C. W. Wilmsen, J. F. Wager (Colorado State University, Fort Collins, Colo.), and R. Singh (McMaster University, Hamilton, Ontario, Canada). *Journal of Applied Physics*, vol. 50, Apr. 1979, p. 2832-2839. 35 refs. Contract No. E(04-3)-1203.

The fabrication and properties of indium tin oxide/p-Si single-crystal solar cells are described. The ITO is deposited by the ion-beam sputtering method. Best photovoltaic devices are obtained when the composition of indium tin oxide (ITO) is 91 mole% and 9 mole% SnO₂. The device properties as a function of the ITO composition will be described. The thickness and the composition of the oxide-silicon interface is critical for device performance. The existence of a thin interfacial layer is demonstrated by Auger spectroscopy. The effect of temperature on device performance and the spectral response are compared with the theory. The SIS model accurately matches the major trends observed in experimental nITO/p-Si solar cells. (Author)

A79-36683 **Comment on a simple measurement of absolute solar cell efficiency.** V. L. Dalal and A. Rothwarf (Delaware, University, Newark, Del.). *Journal of Applied Physics*, vol. 50, Apr. 1979, p. 2980, 2981. 8 refs.

A79-36737 * **Concepts for reducing exhaust emissions and fuel consumption of the aircraft piston engine.** B. J. Rezy, K. J. Stuckas, J. R. Tucker, and J. E. Meyers (Teledyne Continental Motors, Mobile, Ala.). *Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790605*. 35 p. 23 refs. Research supported by the Teledyne Continental Motors; Contract No. NAS3-19755.

A study was made to reduce exhaust emissions and fuel consumption of a general aviation aircraft piston engine by applying known technology. Fourteen promising concepts such as stratified charge combustion chambers, cooling cylinder head improvements, and ignition system changes were evaluated for emission reduction and cost effectiveness. A combination of three concepts, improved fuel injection system, improved cylinder head with exhaust port liners and exhaust air injection was projected as the most cost effective and safe means of meeting the EPA standards for CO, HC and NO. The fuel economy improvement of 4.6% over a typical single engine aircraft flight profile does not though justify the added cost of the three concepts, and significant reductions in fuel consumption must be applied to the cruise mode where most of the fuel is used. The use of exhaust air injection in combination with exhaust port liners reduces exhaust valve stem temperatures which can result in longer valve guide life. The use of exhaust port liners alone can reduce engine cooling air requirements by 11% which is the equivalent of a 1.5% increase in propulsive power. The EPA standards for CO, HC and NO can be met in the IO-520 engine using air injection alone or the Simmonds improved fuel injection system. A.T.

A79-36749 * **A review of Curtiss-Wright rotary engine developments with respect to general aviation potential.** C. Jones (Curtiss-Wright Corp., Wood-Ridge, N.J.). *Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790621*. 23 p. 21 refs. Contracts No. NAS3-20030; No. NAS3-20808.

Aviation related rotary (Wankel-type) engine tests, possible growth directions and relevant developments at Curtiss-Wright have been reviewed. Automotive rotary engines including stratified charge are described and flight test results of rotary aircraft engines are presented. The current 300 HP engine prototype shows basic durability and competitive performance potential. Recent parallel developments have separately confirmed the geometric advantages of the rotary engine for direct injected unthrottled stratified charge. Specific fuel consumption equal to or better than pre- or swirl-chamber diesels, low emission and multi-fuel capability have been shown by rig tests of similar rotary engine. A.T.

A79-36752 **A canister fuel pump for general aviation aircraft.** R. R. Goetz and R. W. Rothfusz (Airborne Manufacturing Co., Elyria, Ohio). *Society of Automotive Engineers, Business Aircraft Meeting and Exposition, Wichita, Kan., Apr. 3-6, 1979, Paper 790624*. 9 p.

A new family of canister-type fuel pumps for use on both rotary and fixed-wing aircraft in general aviation use will be described. The pump, which features a wet-brush DC motor, offers advantages on aircraft where ease of maintenance and minimum downtime is very important. Major features of the new design, pump performance, and maintenance cost savings will be discussed. (Author)

A79-36777 **Doped amorphous silicon and its application in photovoltaic devices.** R. A. Gibson, P. G. Le Comber, and W. E. Spear (Dundee, University, Dundee, Scotland). *IEEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S3-S6. 13 refs.

The paper deals with the development of the new field of substitutionally doped amorphous semiconductors, and discusses the possible application of amorphous silicon in cheap large-area photovoltaic devices. Preparation and doping from the gas phase are described and the properties of an amorphous junction are discussed. (Author)

A79-36778 Amorphous-silicon m.i.s. solar cells. J. I. B. Wilson and J. McGill (Heriot-Watt University, Edinburgh, Scotland). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S7-S10. 26 refs. Research supported by the Wolfson Foundation and Science Research Council.

MIS solar cells of amorphous silicon on stainless steel, with a top barrier contact of Ni/TiO_x, have given 48% power conversion efficiency without an antireflection coating. The insulating layer, with an optimum thickness of approximately 2 nm, compensates for the low work function of nickel compared with platinum, and enables similar high open-circuit voltages (up to 680 mV) to be obtained. The fill factor is not appreciably degraded by the addition of an insulating layer, unless this is thicker than approximately 3 nm. Under illumination, the diode characteristics change compared with their behaviour in the dark; the diode factor, the barrier height, and the series resistance are all dependent on light intensity. (Author)

A79-36779 Doping of sputtered amorphous-silicon solar cells. M. J. Thompson, J. Allison, and M. M. Alkaiisi (Sheffield, University, Sheffield, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S11-S14. 8 refs.

The paper describes the progress that has so far been made in the sputtering of amorphous silicon for solar-cell applications. An alternative form of doping to doping from the gas phase is described. The results obtained are compared with those found for glow-discharge silicon. Finally, a discussion of the relative advantages of sputtering techniques emphasises their considerable potential for commercial exploitation in the production of thin-film solar cells.

(Author)

A79-36780 Silicon solar cells for operation in concentrated sunlight. D. Walsh, J. R. Knight, and E. Asl-Soleimani (Oxford University, Oxford, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S18, S19. 10 refs.

An account is given of the likely applications for silicon solar cells in systems employing optical concentration. The preparation of n(+)-p-p(+) cells from monocrystalline and polycrystalline wafers together with preliminary performance characteristics are reported. A novel type of concentrating solar collector is described. (Author)

A79-36781 Meteorological effects on Schottky-barrier solar cells. C. M. Klimpke and P. T. Landsberg (Southampton, University, Southampton, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S20-S22. NATO-supported research; Grant No. AF-AFOSR-77-3437.

The effect of different meteorological conditions on Schottky-barrier solar-cell outputs has been investigated, using a model for an n-type solar cell. Similar results to those for p-n junction cells have been obtained, namely that although the output power density is reduced, a much higher conversion efficiency is possible when the solar cell is illuminated with diffuse radiation. The effect of the density of interfacial states, and the metal work function, upon the J/V characteristics and on the conversion efficiency is shown to be an important feature of Schottky-barrier solar cells. (Author)

A79-36782 Silicon terrestrial solar photovoltaic installations. A. D. Haigh, D. J. Hemingway, K. Watkin, and A. V. Whale (Ferranti, Ltd., Electronic Components Div., Oldham, Lancs., England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S23-S30. 8 refs. Research supported by the Ferranti Co., Department of Industry, and European Economic Communities.

A survey of work on terrestrial solar photovoltaic installations using silicon solar cells is presented, and three main areas are discussed. First, the possible processing routes for cell manufacture are considered and conclusions arrived at for the lowest-cost route. Secondly, cell encapsulation is considered with reference to the environmental stresses that an encapsulated module must withstand. Thirdly, the computation of installation parameters for minimum cost is described, an installation being defined as a stationary array of modules in conjunction with a rechargeable battery. (Author)

A79-36783 Schottky-barrier versus homojunction silicon solar cells - A status report. W. G. Townsend (Royal Military College of Science, Shrivenham, Wilts., England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S31-S34. 9 refs.

The present state of silicon Schottky-barrier solar cell (s.b.s.c.) development is reviewed and the relative advantages and disadvantages of this type of cell compared with the competing homojunction cell technology. Recent work on cast silicon substrates is considered, and the conclusion drawn that Schottky-barrier cells are not likely to compete unless a wholly thin-film s.b.s.c. can be developed based on the favorable absorption properties of amorphous silicon. A number of problems requiring solution before s.b.s.c. can compete in terms of reliability and low cost for both thick and thin-film cells are discussed. (Author)

A79-36784 Approaches to low-cost solar cells. H. Kressel (RCA Laboratories, Princeton, N.J.). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S35-S39. 28 refs.

Major approaches to the reduction of the costs of solar cells, primarily those based on silicon, are reviewed. The highest efficiency single crystal silicon solar cells (efficiency greater than 15%) are relatively costly and so are under consideration for installations in which solar energy is concentrated. Costs of these structures could be reduced by the simplification and automation of fabrication procedures, by the use of polycrystalline starting materials and by improved crystal growth procedures, however the ultimate cost limitation remains in the bulk silicon materials and the methods needed to prepare wafers. The growth of silicon in ribbon form is considered a potential means of cost reduction, but problems of the limitation of growth by crystal defects must still be overcome. Work is being done on producing efficient thin-film silicon cells on low cost substrates, but no approach has yet produced efficiencies greater than 6% and thin-film devices based on III-V and III-VI compounds, while being of low cost, require further development to attain 10% efficiency. A.L.W.

A79-36785 Solar cells fabricated by ionised-cluster beam technology. T. Takagi, I. Yamada, and A. Sasaki (Kyoto University, Kyoto, Japan). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S40-S48. 28 refs.

It is shown that ionised-cluster beam deposition and epitaxial techniques are useful for the fabrication of photocells. A thin layer of single-crystal silicon and a very thin conductive metal film made by these techniques are used to obtain wide-spectrum sensitivity of the cells. The p-n junction diode has been made by n-type silicon epitaxy onto a p-type silicon substrate. The Schottky-barrier diode has been made by depositing a gold film onto an n-type silicon substrate. These techniques have a high potential for making an ohmic-contact electrode with good adhesion. The alloy process can be eliminated from the fabrication of a photocell. Finally, the current status of solar-cell technology in Japan is reviewed. (Author)

A79-36786 Cadmium-sulphide/copper-sulphide thin-film solar cells - Review of methods of producing the CdS and Cu₂S layers. R. Hill (Newcastle-upon-Tyne Polytechnic, Newcastle-upon-Tyne, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S49-S54. 62 refs.

A79-36787 Thin-film solar cells produced by physical vapour deposition. R. Hill (Newcastle-upon-Tyne Polytechnic, Newcastle-upon-Tyne, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S55-S58. 15 refs.

Theoretical and experimental studies of thin-film solar cells are described. A theoretical model has been developed in which optical interference effects lead to improved photocurrents at small thicknesses of the Cu₂S or CuInSe₂ absorbing layers, and the optical properties of the substrate can have a significant effect on the photocurrent. The results for CdS/Cu₂S and CdS/CuInSe₂ junctions are presented, and it is found that the optimum thickness of the absorbing layer is 0.1-0.15 micron in both cases. The dry-barrier

technique for producing CdS/Cu₂S junctions has been investigated in some detail, and the techniques that have been developed are described. Most of the work with the dry-barrier technique has used thermally evaporated cadmium sulphide, and the efficiency of these cells is estimated to be up to 6%. The more recent work on junction formation on sputtered cadmium sulphide is also described briefly. (Author)

A79-36789 Order-disorder transformations and the nature of the copper-sulphide layer in Cu/xS/CdS solar cells. A. Putnis (Cambridge University, Cambridge, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S62-S64. 14 refs. Research supported by the National Environment Research Council.

The evidence that the two copper-sulphide phases, chalcocite and djurite, can exist at the same compositions near Cu₂S is briefly reviewed. Experimental data suggest that djurite is the more stable phase at room temperatures and that a polymorphic chalcocite to djurite transformation may take place in the thin copper-sulphide layers present in solar cells. The kinetics of this transformation are discussed and related to low-temperature phase equilibria in the Cu/S system around Cu₂S, and to the processes that may operate in solar cells. (Author)

A79-36791 p-InP/n-CdS heterojunction solar cells. T. J. Coutts and K. J. Lawson (Cranfield Institute of Technology, Cranfield, Beds., England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S67, S68. 5 refs.

For photovoltaic collector arrays, heterojunction devices should be studied more extensively. The advantages of the InP/CdS cell are outlined, both as single-crystal InP with deposited CdS and as an all-thin-film cell. Present work on the single-crystal InP with sputter-deposited CdS is described, and plans are given for polycrystalline thin films using RF sputtering. (Author)

A79-36792 Solar eyeball - An automatic sun-tracking concentrator for use with photovoltaic generators. D. H. Mash and P. W. Ross (Standard Telecommunication Laboratories, Ltd., Harlow, Essex, England). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S74-S78.

A solar-electric conversion module is described which uses a plastic Fresnel lens to concentrate sunlight onto a group of GaAs/GaAlAs solar cells mounted on a heat sink. The necessary ability to track the sun is achieved by using a novel pneumatic system powered by solar energy. When the solar eyeball is misaligned, the sun's image falls on a heat exchanger in one of two air reservoirs adjacent to the cells; the resulting expansion forces a magnetized piston against a fixed external magnetic field, thereby causing the entire module to rotate until the solar cells are again in the focus. The design is simple and potentially inexpensive. Attention is given to details of the magnetic piston, the optics of the solar-eyeball system, and the thermodynamics of the heat exchangers, as well as an estimate of eventual costs. S.D.

A79-36793 Analysis of an edge-illuminated graded-gap solar cell. J. E. Parrott (University of Wales Institute of Science and Technology, Cardiff, Wales). *IEE Journal on Solid-State and Electron Devices*, vol. 2, June 1978, p. S79-S82. 7 refs.

It has been established that even under ideal conditions the efficiency of a semiconductor photovoltaic cell with a single energy gap cannot exceed approximately 30%. One possible configuration for avoiding this limitation is the edge-illuminated graded-gap solar cell, in which the plane of the p-n junction is parallel to the incident radiation and the gap is graded from a larger value at the illuminated surface to a smaller at the back. Calculations were carried out for (1) fixed front-surface energy gap and variable back-surface gap, and (2)

fixed back-surface gap and variable front-surface gap. In each case the fixed gap was 1.47 eV. The best result was an increase of theoretical efficiency from 27.2 to 28.3% for the first case with a back-surface gap of 1.27 eV at a thousand suns. To increase the efficiency further it would be necessary to segment the device. (Author)

A79-36806 Hall effect in an induction discharge. A. P. Zhilinskii, B. V. Kuteev, A. S. Smirnov, and R. Sh. Tikhvatulin (Leningradskii Politekhnikeskii Institut, Leningrad, USSR). (*Zhurnal Tekhnicheskoi Fiziki*, vol. 48, Oct. 1978, p. 2044-2046.) *Soviet Physics - Technical Physics*, vol. 23, Oct. 1978, p. 1166, 1167. Translation.

It is shown experimentally that large values of the Hall parameter can be obtained in an electrodeless dc discharge. In this case, the plasma, formed directly in the magnetic field, was quasi-stationary. Measurements were carried out always in the active stage of the discharge, so that the influence of plasma decay on the measurement of the effective Hall parameter was eliminated. V.P.

A79-36812 Combustion-products turbulence in the channel of an MHD generator. A. I. Bystryi, R. V. Ganefel'd, and V. B. Red'kin (Akademiia Nauk Ukrainskoi SSR, Institut Elektrodinamiki, Kiev, Ukrainian SSR). (*Zhurnal Tekhnicheskoi Fiziki*, vol. 48, Oct. 1978, p. 2074-2079.) *Soviet Physics - Technical Physics*, vol. 23, Oct. 1978, p. 1182-1185. 6 refs. Translation.

In the experiment described, the level and scale of turbulence and its correlation and spectral characteristics were studied for a combustion product plasma in an MHD channel. The manner in which the magnetic and electric fields affect the turbulence structure is illustrated. V.P.

A79-36815 Theory of the pulsed operation of a thermionic converter. II - Ionization stage. V. A. Zherebtsov and V. D. Talanova. (*Zhurnal Tekhnicheskoi Fiziki*, vol. 48, Oct. 1978, p. 2103-2112.) *Soviet Physics - Technical Physics*, vol. 23, Oct. 1978, p. 1201-1206. 11 refs. Translation.

The ionization process occurring in a thermionic energy converter operating in the pulsed mode is analyzed in the case where a negative voltage pulse is applied to the anode. In the case of a one-component filling of the diode, ions are produced in the anode sheath. This impairs considerably the effectiveness of their utilization during the plasma decay stage. When the diode is filled with heavy inert gases, the energy losses by ion production are as high as 60 eV. In the case of a two-component filling, the ionization region widens while the energy losses by ion production are reduced. V.P.

A79-36876 Plasma surface interactions in controlled fusion devices; Proceedings of the Third International Conference, Abingdon, Oxon, England, April 3-7, 1978. Conference sponsored by the U.K. Atomic Energy Authority. Edited by G. M. McCracken, P. E. Stott (Atomic Energy Research Establishment, Culham Laboratory, Abingdon, Oxon, England), and M. W. Thompson (Sussex University, Brighton, England). *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978. 660 p.

Surface processes in plasma-wall interactions in tokamak devices are discussed, with special emphasis on impurity behavior and control in tokamak plasmas. Attention is given to physical and chemical sputtering; blistering; recycling; refueling; trapping and gas release; ion scattering at surfaces; and surface interactions in reactors. Also discussed are the use of magnetic divertors for impurity control, boundary-layer problems, surface preparation and cleaning, experimental techniques for tokamak analysis, and relevant first-wall processes. S.D.

A79-36877 Surface processes in plasma wall interactions. W. Bauer (Sandia Laboratories, Livermore, Calif.). (*U.K. Atomic*

Energy Authority, International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 3-15. 36 refs. Research supported by the U.S. Department of Energy.

Plasma surface interactions play a critical role in all tokamak experiments. Phenomena such as impurity influx and radiation, H isotope recycling and first wall modification have become widely recognised in the past year of tokamak operation. It is now generally recognised that impurities are introduced through sputtering, arcing desorption and other mechanisms. In future DT devices, helium blistering may assume an important role. Examples and the relative importance of these various surface processes are discussed. Another critical area for tokamak operation involves hydrogen isotope trapping at the first wall. Recent experiments on several tokamaks indicate that trapping and subsequent re-emission of hydrogen isotopes on walls during and between discharges play an important role in fuel balance, performance and eventually in the tritium inventory. Existing data and understanding of H/D trapping and re-emission phenomena are reviewed. (Author)

A79-36878 Progress in tokamak and stellarator experiments. R. J. Bickerton (EURATOM and U.K. Atomic Energy Authority Fusion Association, Culham Laboratory, Abingdon, Oxon, England). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.*) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 16-29. 26 refs.

To a tokamak physicist the stellarator is a device with a controllable q profile and with the ability to reduce the plasma current in order to assess the significance of current-driven modes. To the stellarator specialist the tokamak is a device on which diagnostic, heating and impurity-control techniques can be developed for eventual application to the stellarator. The discussion focuses on progress in understanding and progress in parameters achieved with these two systems. Tokamaks are discussed relative to scaling, equilibrium, fluctuation in tokamak plasmas, impurities and plasma-wall interactions, tokamak operating regimes, energy balance and anomalous losses, and auxiliary heating. Stellarators are examined with respect to equilibrium, fluctuations in stellarator plasma, containment in stellarator plasma, auxiliary heating and plasma production, and impurities and recycling. S.D.

A79-36879 Review of plasma wall interactions in tokamaks. P. Ginot (EURATOM and Commissariat à l'Énergie Atomique sur la Fusion, Département de Physique du Plasma et de la Fusion Contrôlée, Fontenay-aux-Roses, Hauts-de-Seine, France). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.*) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 30-40. 50 refs.

Plasma wall interactions have been recognized as an important topic since early tokamak machines. Reactor calculations and the search for scaling laws recently gave a new impetus to this subject. Better control of both the light and heavy impurities is now obtained. In the last two years the effective ionic charge has been reduced to almost one in present machines. Details are given comparing the results from different laboratories. Pre-cleaning and gettering of the walls as well as lowering the temperature of the edge plasma have proved to be efficient. Comments are made on future developments. (Author)

A79-36880 Surface interactions and conditioning techniques in tokamaks. R. J. Taylor (California, University, Los Angeles, Calif.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.*) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 41-44. 7 refs. Contract No. EY-76-03-G010-PA-26. DOE Task V.

It now appears that the removal of oxygen from the surfaces of a fusion device requires a carefully generated hydrogen plasma where chemical effects are allowed to dominate. Two critical parameters must be considered: (1) the plasma temperature, and (2) the plasma-wall sheath potential. Increasing either of these two beyond

certain values reduces that rate at which oxygen is removed (in the form of H₂O). For best results, the bulk outgassing must be reduced by baking the chamber at moderate temperatures as in other high vacuum applications. Oxygen applied to the surfaces results in a corresponding increase in the oxygen level in the plasma, while impurities in the filling gas do not normally play a significant role. Effective surface densities close to 1% of a monolayer have been obtained. (Author)

A79-36881 Divertor experiments for controlling plasma-wall interactions. Y. Shimomura and H. Maeda (Japan Atomic Energy Research Institute, Tokai, Ibaraki, Japan). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.*) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 45-58. 38 refs.

A greater part of the history of fusion research on magnetic confinement consists of successive attempts to realize the insulation of a confined hot plasma from the surrounding walls to avoid harmful impurity contamination. The present status of magnetic-divertor experiments in tokamak devices and the application of a divertor to a large fusion device are discussed. The origin of impurities is examined, and the types of magnetic divertor in tokamaks together with related experiments on the stability of divertor field configuration are described. Attention is given to the effects of a divertor on a main plasma, and to the scrape-off layer plasma. Impurity control and the divertor in a large fusion device are considered. The important divertor actions demonstrated are reduction of plasma-wall interactions, shielding impurity influx and impurity back-flow, and fuel- and ash-exhaust and refueling. S.D.

A79-36882 Recycling processes in tokamaks. E. S. Marmor (MIT, Cambridge, Mass.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.*) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 59-67. 36 refs. Contract No. EG-77-G-01-4108.

This review is mainly concerned with measurements of the recycling of the working gas in tokamaks, and addresses the associated questions of impurity recycling and wall conditioning. Techniques used in studying this recycling are described and the major findings are reported. The experiments include (1) changing between hydrogen and deuterium as the working gas and observing changes in plasma and wall constituents; (2) spectroscopic measurements of radiation from neutral hydrogen; (3) residual gas analysis; and (4) sample surface probes. It is found that recycling rates are strongly dependent on the condition of the wall prior to tokamak operation, as affected by baking, discharge cleaning, and titanium gettering. In addition, the wall condition and recycling rates can also change profoundly due to tokamak discharges. There appears to be a correlation between hydrogen recycling and the influx of impurities, particularly gaseous O compounds. S.D.

A79-36883 Tokamak plasma diagnosis by surface physics techniques. S. A. Cohen (Princeton University, Princeton, N. J.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.*) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 68-77; Discussion, p. 77. 30 refs. Contract No. EY-76-C-02-3073.

The utilization of elementally-sensitive surface techniques as plasma diagnostics is discussed with emphasis on measuring impurity fluxes, charge states, and energy distributions in the plasma edge. A model of plasma flow to the probe is presented and applied to the interpretation of data. Limits on time and energy resolution, and sensitivity are given. The overlap of these techniques with conventional plasma diagnostics is described. (Author)

A79-36884 Surface effects and impurity production in tokamak machines. P. Staib and G. Staudenmaier (EURATOM and Max-Planck-Institut für Plasmaphysik, Garching, West Germany).

(U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978). *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 78-91. 75 refs.

Recent investigations of plasma-wall interactions have confirmed the earlier assumption that the interactions occur only in the topmost atomic layers of the wall, and so emphasize the major role of surface physics on this field. These investigations have further shown that besides atomic processes, such as desorption or sputtering, other processes occur, extending on a microscope rather than an atomic scale. These are for example evaporation, arching, and mechanical stress. Both aspects are discussed as far as possible in a quantitative way. The contribution of most probable processes is estimated using data available on flux and energy of particles and yields of single processes. We reach the conclusion that no process can be disregarded. Several processes seem to contribute to the impurity release and are different at different phases of the discharge. An interdependence between these processes is likely.

(Author)

A79-36885 Impurity behaviour in real and simulated tokamak plasmas. A. Gibson. (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 92-102. 30 refs.

A fusion reactor based upon the tokamak principle will only be possible if methods can be developed for controlling the impurity influx so as to maintain an extremely low level of radiating impurity in the plasma. The last few years have seen remarkable experimental progress in this area, so that whereas, even three years ago it was difficult to find a hot tokamak plasma with an effective Z value less than 4 or 5, many tokamaks now routinely produce $Z(\text{eff})$ close to one. Over a similar period, work with numerical simulation codes has shown that, even for a fixed transport model, the accumulation of impurities in central or in edge regions is determined by density and temperature profiles, which in turn are determined by a complicated interplay of transport, radiation and power deposition. Some calculations have shown that in these circumstances profiles can be manipulated by controlling the power and particle deposition and that as a result the impurity influx can be limited. The present paper presents a review of recent progress in the field.

(Author)

A79-36886 First wall and divertor plate material selection in fusion reactors. R. W. Conn (Wisconsin, University, Madison, Wis.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978). *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 103-111. 34 refs. Research supported by the U.S. Department of Energy and Wisconsin Electric Utilities Research Foundation.

The criteria for selecting first wall materials in magnetic and inertial confinement fusion reactors are discussed. These criteria include radiation damage, compatibility, thermomechanical properties, fabricability, joining, industrial capability, the existing data base, cost, induced radioactivity, and resource availability. At present, stainless steel remains the primary choice for a structural material because of the large existing data base and industrial capability. Titanium and vanadium alloys are the primary backup materials. The influence of surface heating on the allowable neutron wall loading is described in detail for magnetic and ICF reactors. The use of divertors may permit reactors to operate with higher neutron wall loadings but heat transfer and excessive wall erosion by sputtering of the collector plates are fundamental problems requiring resolution before divertors are employed in reactors.

(Author)

A79-36887 Plasma-surface interactions in Q-enhanced mirror fusion systems. R. F. Post (California, University, Livermore, Calif.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978). *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 112-126. 24 refs. Contract No. W-7405-eng-48.

Two approaches to enhancement of the Q (energy gain) factor of mirror systems are under study at Livermore. These include the Tandem Mirror and the Field Reversed Mirror. Both of these new ideas preserve features of conventional mirror systems as far as plasma-wall interactions are concerned. Specifically in both approaches field lines exit from the ends of the system and impinge on walls located at a distance from the confinement chamber. It is possible to predict some aspects of the plasma-surface interactions of TM and FRM systems from experience obtained in the Livermore 2XIIIB experiment. In particular, as observed in 2XIIIB, effective isolation of the plasma from thermal contact with the ends owing to the development of sheath-like regions is to be expected. Studies presently underway directed toward still further enhancing the decoupling of the plasma from the effects of plasma surface interactions at the walls will be discussed, with particular reference to the problem of minimizing the effects of refluxing secondary electrons produced by plasma impact on the end walls. (Author)

A79-36892 Sputtering yields of graphite and carbides and their potential use as first wall materials. J. Bohdansky, H. L. Bay, and W. Ottenberger (EURATOM and Max-Planck-Institut für Plasma-physik, Garching, West Germany). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 163-167. 18 refs. Contract No. EURATOM-JET-C-25-GI-181.

The sputtering yields of graphite, B₄C, SiC and TiC have been measured at normal incidence for H, D and He(4) ions in the energy range between 100 and 8 keV. The yields are energy dependent and display a maximum for all target-ion combinations within the energy range investigated. The maximum yield values are strongly dependent on the mass of the bombarding ions, but show only a weak influence on the target materials. The consequences of this behavior for the potential use of these materials as a first wall are discussed under the assumption that the plasma is generated mainly by sputtering. Particular attention is given to the importance of the plasma edge temperature with respect to the choice of a first wall material and the relative advantage of the materials investigated as compared to several metals (stainless steel, inconel, molybdenum). (Author)

A79-36893 Low energy hydrogen and deuterium sputtering measurements of stainless steel, graphite, and beryllium oxide. J. A. Borders, R. A. Langley (Sandia Laboratories, Albuquerque, N. Mex.), and K. L. Wilson (Sandia Laboratories, Livermore, Calif.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 168-174. 12 refs. Contract No. AT(29-1)-789.

Ion backscattering techniques were used to measure the sputtering coefficients of deuterium on polycrystalline graphite and thermally prepared BeO, the materials considered for the first wall of tokamak reactors. Reliability of this method, which uses implanted Xe marker techniques, was checked by measurements of the hydrogen and deuterium sputtering coefficients of 304 stainless steel and comparing them with the existing data obtained by the weight loss technique. The experimental method and sample preparation are described, and the new data determined that the sputtering yields of deuterium on carbon and BeO range from 0.016 to 0.052 atoms/ion. A previously proposed semi-empirical curve derived from theory and fitted to existing physical sputtering data confirms the stainless steel data, but the data for hydrogen and deuterium sputtering of carbon and BeO are substantially greater than predicted by the semi-empirical theory. A.T.

A79-36927 Suprathermal alpha transport and wall bombardment in tokamaks. G. H. Miley and L. M. Hively (Illinois, University, Urbana, Ill.). (U.K. Atomic Energy Authority, *International Conference on Plasma Surface Fusion Devices*, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 389-395. 27 refs.

Fusion-product transport, from an axisymmetric tokamak plasma to the first wall, is modelled. Prompt-loss profiles (i.e. prior to slowing) are calculated as a function of poloidal angle. There is a significant flux incident at near-grazing angles, thus enhancing sputtering. Non-prompt losses are also obtained; the resulting wall bombardment is approximately one tenth of the prompt contribution, but is localized at the outboard edge of the tokamak. To verify fusion-product transport, a detection experiment has been proposed and modelled for a device like PLT or TFTR. Blistering is the dominant wall erosion mechanism. Serious impurity contamination of the plasma can result. These effects can be minimized by: (1) periodic B-field reversal, (2) special wall materials and/or rapid wall replacement designs in peak flux areas, (3) increased plasma-wall separation, and (4) increased plasma current. (Author)

A79-36945 Numerical modeling of impurity effects. J. T. Hogan and A. T. Mense (Oak Ridge National Laboratory, Oak Ridge, Tenn.). (U.K. Atomic Energy Authority, International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 508, 509. 6 refs.

The present paper deals with the effects of iron, molybdenum, tungsten, oxygen, and/or titanium on the overall energy balance in tokamak experiments. In the present paper, some areas in which numerical modeling could provide useful additional data are examined. V.P.

A79-36965 Oxygen adsorption on stainless steel. G. Luzzi and L. Papagno (Calabria, Università, Cozzenza, Italy). (U.K. Atomic Energy Authority, International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 614-616.

Results of an experiment show that it is difficult to completely eliminate oxygen impurities from stainless steel toroidal devices of plasma reactors. Two samples of different types of stainless steel were used during the etching, excitation and heating of the surfaces, bombarding them with noble gas ions in conditions of variable oxygen pressure in the experimental chamber. Oxygen adsorption measurements were performed by Auger techniques and ion etching techniques were used in the investigation of the elemental depth profile of the samples. It is concluded that oxygen ions present in the plasma are readsorbed on the walls due to a great affinity for oxygen of bombarded heated stainless steel. V.T.

A79-36969 Laser-induced desorption experiments with technical metal surfaces. H. Hartwig, P. Mioduszewski, and A. Pospiesznyk (EURATOM and Kernforschungsanlage Jülich GmbH, Institut für Plasmaphysik, Jülich, West Germany). (U.K. Atomic Energy Authority, International Conference on Plasma Surface Fusion Devices, 3rd, Abingdon, Oxon, England, Apr. 3-7, 1978.) *Journal of Nuclear Materials*, vol. 76-77, Sept.-Oct. 1978, p. 625, 626.

The method of laser-induced thermal desorption is proposed for in situ analysis of the composition of adsorbed gas layers on the wall of a fusion device. A procedure is described which allows remote determination of the achieved target temperature - a very important parameter for the desorption of gases. The adsorption characteristics of the Ni/CO and Ni/H₂ systems are assessed experimentally. The measurements obtained demonstrate that the present experimental laser desorption apparatus is suitable for reliable studies of the adsorption-desorption process. S.D.

A79-37000 Fusion research - The temperature rises. M. Kenward. *New Scientist*, vol. 82, May 24, 1979, p. 626-630.

Problems in the development of fusion reactors include lack of plasma equilibrium, lack of MHD stability, microinstability, radiation losses and classical particle diffusion and heat conduction across the magnetic field. MHD instability was overcome by the tokamak

confinement scheme; control of microinstabilities or kinetic instabilities is still being investigated. Particular attention is given to neutral beam injection and RF heating schemes adopted for the Princeton Large Torus. J.M.B.

A79-37072 Hydrogen production from coal, water and electrons. R. W. Coughlin and M. Farooque (Connecticut, University, Storrs, Conn.). *Nature*, vol. 279, May 24, 1979, p. 301-303. 9 refs. Research supported by the University of Connecticut and U.S. Department of Energy.

The paper reports on a newly developed electrochemical process which converts coal and water into two separate gaseous products: one comprising essentially gaseous oxides of carbon and the other essentially pure hydrogen. The process chemistry takes place at mild temperatures and the gaseous products are essentially free of impurities such as tar, ash and sulfur compounds. This electrochemical gasification process involves the anodic oxidation of coal at an electrode. P.T.H.

A79-37155 Chemical vapor deposition of spectrally selective surfaces for high-temperature photothermal conversion. B. O. Seraphin (Arizona, University, Tucson, Ariz.). (American Vacuum Society, National Symposium, 25th, San Francisco, Calif., Nov. 27-Dec. 1, 1978.) *Journal of Vacuum Science and Technology*, vol. 16, Mar.-Apr. 1979, p. 193-196. 16 refs. Contracts No. EY-76-S-04-3709; No. ER-78-S-02-4899.

Chemical vapor deposition (CVD) was used to produce multi-layer photothermal converters with step-function profile of optical absorption in the form of high absorption for short wavelengths and vanishing absorption for long ones. The converter stack is made up of the following layers: AR layer (Si₂N₄), absorber (Si), diffusion barrier stabilizer (Cr₂O₃), reflector (Ag), diffusion barrier buffer (oxide), and substrate. Auger spectroscopy, microprobe, and X-ray diffraction analysis were used to characterize the films. Data presented include the reflectance measured against aluminum reference; absolute reflectance of bulk molybdenum and a molybdenum film sputtered in ultrahigh vacuum; reflectance measured against an aluminum reference of a CVD molybdenum film doped with MoO₃ to generate sufficient solar absorption in a film of high IR reflectance; and absorption coefficient of a series of Si films deposited by pyrolytic decomposition of silane onto fused silica substrates held at various temperatures. P.T.H.

A79-37156 Formation of thin Cu₂S /chalcocite/ films using reactive sputtering techniques. G. A. Armantrout, D. E. Miller, K. E. Vindelov, and T. G. Brown (California, University, Livermore, Calif.). (American Vacuum Society, National Symposium, 25th, San Francisco, Calif., Nov. 27-Dec. 1, 1978.) *Journal of Vacuum Science and Technology*, vol. 16, Mar.-Apr. 1979, p. 212-215. Contract No. W-7405-eng-48.

Thin Cu₂S (chalcocite) films, which are of interest for solar cell fabrication, have been prepared using reactive sputtering techniques. The copper-sulfur system, which is multiphasic and polymorphic, is difficult to form in the orthorhombic chalcocite phase. This phase can be achieved by careful control of substrate temperature and the partial pressure of H₂S in the sputtering atmosphere. Sulfur-rich atmospheres produce the sulfur-rich Cu(x)S phases which are unsuitable for solar cell fabrication, whereas sulfur-lean atmospheres result in precipitated copper cones on the surface. Epitaxial chalcocite films have been formed on single-crystal CdS substrates. Charge transport studies in polycrystalline Cu(x)S films formed on polycrystalline CdS indicate minority carrier diffusion lengths of 100 nm which are adequate for solar cell operation. The sputtering parameters affecting film formation (H₂S concentration, substrate temperature and bias, and substrate material) have been studied and are discussed. (Author)

A79-37157 Technique to determine the growth rate and resistivity of evaporated CdS thin films. N. K. Annamalai, C. C.

Chao, and D. Raymond (Clarkson College of Technology, Potsdam, N.Y.). (*American Vacuum Society, National Symposium, 25th, San Francisco, Calif., Nov. 27-Dec. 1, 1978.*) *Journal of Vacuum Science and Technology*, vol. 16, Mar.-Apr. 1979, p. 222-225. 14 refs. NSF Grants No. ENG-78-06263; No. SEP-77-26562.

An in situ resistance measurement technique is described which was used to determine the resistivity and thickness of various layers of CdS films to be used in solar cell fabrication. A simple mathematical procedure was used to calculate the thickness and resistivity of the film during the growth process. This procedure was also used to monitor CdS films grown under different substrate temperatures and source powers. The variation of film characteristics with deposition parameters have been measured and the results correlate well with activation energy measurements. (Author)

A79-37158 Relationship of optical degradation to surface morphology changes in solar absorbers. G. Zajac and A. Ignatiev (Houston, University, Houston, Tex.). (*American Vacuum Society, National Symposium, 25th, San Francisco, Calif., Nov. 27-Dec. 1, 1978.*) *Journal of Vacuum Science and Technology*, vol. 16, Mar.-Apr. 1979, p. 233-235. 8 refs. Research supported by the U.S. Department of Energy and University of Houston.

The physical basis for high-temperature optical degradation of electrodeposited black chrome coatings has been investigated via scanning electron microscopy and Auger electron spectroscopy coupled with inert gas depth profiling. Severe oxidation of the metallic chromium in the coatings has been observed and it is believed to result in shape changes of the particles comprising the film thereby decreasing their near-IR absorptance as is observed for air heat-treated coatings. (Author)

A79-37159 Effect of grain boundaries on the performance of polycrystalline tunnel MIS solar cells. R. Singh, T. N. Bhar (Howard University, Washington, D.C.), J. Shewchun, and J. J. Loferski (Brown University, Providence, R.I.). (*American Vacuum Society, National Symposium, 25th, San Francisco, Calif., Nov. 27-Dec. 1, 1978.*) *Journal of Vacuum Science and Technology*, vol. 16, Mar.-Apr. 1979, p. 236-239. 15 refs. Contract No. EG-77-C-03-1712.

Tunnel MIS solar cells utilizing polycrystalline semiconductors are an attractive alternative to conventional p-n junction devices for fabricating large-scale solar energy conversion arrays. The main effect of the grain boundaries in polycrystalline semiconductors is to reduce the lifetime of the minority carriers. Experimental work indicates that the potential barrier near the grain boundary has a very limited effect on the barrier height which, in turn, controls open-circuit voltage of the device. The collection efficiency depends upon the grain size of the crystallites, in addition to other device parameters. A simple description of the performance of polycrystalline MIS solar cells is presented, based on the above mentioned electrical characteristics. (Author)

A79-37262 Drift wave propagation and convective wave growth in tokamaks. W. Horton, Jr. (Texas, University, Austin, Tex.). *Plasma Physics*, vol. 21, May 1979, p. 455-475. 17 refs. Contract No. AT(40-1)-4478.

The propagation and convective growth of drift waves in tokamak plasmas is investigated with ray trajectory methods. Calculation of the confinement condition for the rays is shown to lead to a shear stabilization criterion previously derived from normal mode theory. For confined ray trajectories quantization of the net change in wave phase leads to the eigenfrequencies of the system. (Author)

A79-37264 An experimental determination of the parallel electron velocity distribution during strong turbulence. R. Stinnett and P. Phillips (Texas, University, Austin, Tex.). *Plasma Physics*, vol. 21, May 1979, p. 491-503. 10 refs. Contract No. EY-77-C-05-4478.

The parallel electron velocity distribution during strong turbulence in the TTT was measured with an $E \times B$ electron velocity

analyzer. Two discharge conditions were studied: 60-70 kA ringing current and 30-35 kA crowbarred current. Electron distributions obtained were used in moment calculations to determine macroscopic parameters such as electron density, temperature, and drift velocity, current density, and total energy. One-dimensional heating observed in the direction of electron current is in agreement with simulation predictions of Biskamp and Chodura (1973). High energy tail formation observed in the present experiment is not predicted, however, in simulations. Excellent agreement was obtained between the measured electron velocity distributions and the results of Thomson scattering, microwave radiation, X-ray, and current penetration measurements. P.T.H.

A79-37265 A source of error in cusp plasma leak measurements. R. Jones (Natal, University, Durban, Republic of South Africa). *Plasma Physics*, vol. 21, May 1979, p. 505-508. 20 refs. Research supported by the South African Atomic Energy Board.

New line cusp leak width measurements in a multidipole plasma device are reported. It was found that plasma inhomogeneity modifies the ion temperature in surface magnetic cusps. This leads to a situation where the parallel ion temperature does not equal the perpendicular ion temperature. The leak parameter was measured to be 2 plus or minus 0.5 mm and 3.5 plus or minus 1 mm for cusps of 700 G and 400 G, respectively. P.T.H.

A79-37272 Effects of cations on the performance of the photoanode in the n-GaAs/K₂Se-K₂Se₂-KOH/C semiconductor liquid junction solar cell. B. A. Parkinson, A. Heller, and B. Miller (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). *Electrochemical Society, Journal*, vol. 126, June 1979, p. 954-960. 19 refs.

Cations adsorbed on n-GaAs affect the fill factor and the open-circuit voltage of the n-GaAs/0.8M K₂Se-0.1M K₂Se₂-1M KOH/C cell. An AM1 solar-to-electrical conversion efficiency of 12% is reached by chemisorbing Ru(III) on the photoanode. This efficiency is maintained upon passage of 35,000 C/sq cm. The effect of Ru(III) is interpreted as a reaction with a surface chemical entity associated with a surface state near the conduction band, which shunts the cell by allowing electrons to tunnel through the barrier at the junction. Reaction with Ru(III) converts the shunting surface state to one to which electrons cannot tunnel. Being strongly adsorbed, Ru(III) also reduces the effect of certain impurities such as Bi(III) which otherwise decrease the power output. (Author)

A79-37273 Migrational polarization in high current density molten salt battery and fuel cell analogs. J. Braunstein and C. E. Vallet (Oak Ridge National Laboratory, Oak Ridge, Tenn.). (*Electrochemical Society, Meeting, Philadelphia, Pa., May 8-13, 1977.*) *Electrochemical Society, Journal*, vol. 126, June 1979, p. 960-965. 23 refs. Contract No. W-7405-eng-26.

Application of the diffusion-migration equation to batteries and fuel cells with mixed molten salt electrolytes indicates the likelihood of composition gradients of magnitude dependent on current density, electrode separation, initial electrolyte composition, interdiffusion coefficient, transference number, and electrode reaction. These gradients can progress to phase separation, to chronopotentiometric transition, or to the establishment of a steady state. (Author)

A79-37285 Fuel release from solid fossil-fuel deposits by electrical induction heating. S. T. Fisher (F. T. Fisher's Sons, Ltd., Montreal, Canada). *Applied Energy*, vol. 5, Apr. 1979, p. 101-113.

The solid fossil fuels are nonmagnetic electrical partial conductors with relatively high electromagnetic loss factors and therefore absorb energy efficiently from an alternating electromagnetic field. The electrical induction heating of fossil-fuel deposits permits low-cost, clean production in situ of petroleum, natural gas, coal tar and electricity on large scales. Physical and chemical data and laboratory investigations indicate the technical and economic feasibility of the processes. (Author)

A79-37286 The impact of price expectations on the demand for electrical energy in the United States. N. D. Uri (U.S. Department of Energy, Oil and Gas Analysis Div., Washington, D.C.). *Applied Energy*, vol. 5, Apr. 1979, p. 115-125. 11 refs.

Given the variability of the price of electrical energy over the past several years, the consumer has been put in a position of not knowing precisely from one month to the next what the price of electrical energy will be. Consequently, this paper hypothesizes a relationship between the expected price and kilowatt-hour sales. The results indicate that 'static expectations seem to be the rule with regard to price and that more than 65 percent of price changes are regarded as permanent by consumers. (Author)

A79-37299 High temperature solar thermoelectric generator. K. P. Suleebka (University of Wales Institute of Science and Technology, Cardiff, Wales). *Applied Energy*, vol. 5, Jan. 1979, p. 53-59. 6 refs. Research supported by the Science Research Council.

The performance of a sintered Si-Ge thermoelectric generator is assessed by computing power output per unit area and the efficiency of thermoelectric conversion. Previously developed high temperature solar energy absorbers were used. The power output and efficiency are considerably improved by using a water- or vapor-cooled heat sink in place of a radiative heat sink. The power density in the thermoelectric generator compares well with those in photovoltaic heterojunction cells using concentrated solar energy. (Author)

A79-37661 Investigation of the maximal heat-transmitting power of heat pipes with metal-fiber wicks. M. G. Semena and A. N. Gershuni (Kievskii Politekhnikeskii Institut, Kiev, Ukrainian SSR). (*Teplofizika Vysokikh Temperatur*, vol. 16, Sept.-Oct. 1978, p. 1060-1067.) *High Temperature*, vol. 16, no. 5, Mar. 1979, p. 899-905. 11 refs. Translation.

A method is proposed for the calculation of maximal (with respect to capillary transport) heat fluxes for heat pipes with metal-fiber wicks. The results of the calculations are compared with experimental data obtained for twenty heat pipes with different constructional characteristics. (Author)

A79-37667 An optical evaluation laboratory for laser fusion. J. L. Munroe and G. Woodfin (California, University, Los Alamos, N. Mex.). In: Optical components: Manufacture and evaluation; Proceedings of the Seminar, Los Angeles, Calif., January 22, 23, 1979. Bellingham, Wash., Society of Photo-Optical Instrumentation Engineers, 1979, p. 9-13. Research supported by the U.S. Department of Energy.

The Antares CO2 laser system is being constructed at LASL to investigate inertial confinement fusion. Antares will contain thousands of optical components, predominantly copper-plated mirrors and sodium chloride windows. In order to coordinate the specification, procurement, evaluation, and disposition of these components, a centralized Optical Evaluation Laboratory (OEL) is being set up. The OEL is mainly a quality-control facility for routinely evaluating the optical performance of components and assemblies with apertures of up to 18-in. diameter. B.J.

A79-37668 Optical characterization of high energy laser components. G. A. Willinski (Dayton, University, Dayton, Ohio). In: Optical components: Manufacture and evaluation; Proceedings of the Seminar, Los Angeles, Calif., January 22, 23, 1979.

Bellingham, Wash., Society of Photo-Optical Instrumentation Engineers, 1979, p. 14-21. 5 refs. Contract No. F29601-76-C-0140.

Techniques for assessing the performance of optical components for infrared high energy laser systems are described. The techniques include photometry and interferometry of large aperture components, diffraction grating efficiency measurements, absorption calorimetry, and reflectometry. A brief summary of the methodology of each type of measurement is presented. (Author)

A79-37670 High-energy laser mirror thermal distortion testing techniques. J. Gierloff (Dayton, University, Dayton, Ohio; USAF, Weapons Laboratory, Kirtland AFB, N. Mex.). In: Optical components: Manufacture and evaluation; Proceedings of the Seminar, Los Angeles, Calif., January 22, 23, 1979.

Bellingham, Wash., Society of Photo-Optical Instrumentation Engineers, 1979, p. 44-50. Contract No. F29601-77-C-0002.

Mirrors are tested at the Thermal Distortion Test Facility (TDTF), Kirtland AFB, Albuquerque, N. Mex., using a rastered electron beam (E-beam) to thermally load the mirrors. Typical test results and their implications are presented. The capabilities and accuracies of the facility are discussed. Verification tests performed with a CO2 laser confirm the validity of using a rastered E-beam to simulate a HEL beam thermal loading. (Author)

A79-37685 Ion-implanted laser-annealed GaAs solar cells. J. C. C. Fan, R. L. Chapman, J. P. Donnelly, G. W. Turner, and C. O. Bozler (MIT, Lexington, Mass.). *Applied Physics Letters*, vol. 34, June 1, 1979, p. 780-782. 10 refs. USAF-sponsored research.

Conversion efficiencies up to 12% at AM1 have been obtained for ion-implanted laser-annealed (IILA) GaAs solar cells utilizing a shallow-homojunction h(+)/p/p(+) structure without a GaAlAs window. The n(+) layer was formed by Se(+)-ion implantation into the p layer, which was grown epitaxially by chemical vapor deposition on a single-crystal p(+) substrate. The implanted layer was annealed, without encapsulation, by scanning with a CW Nd:YAG laser. Cell metallization was performed by electroplating, and an antireflection coating was formed by anodic oxidation of the n(+) layer. (Author)

A79-37686 655 mV open-circuit voltage, 17.6% efficient silicon MIS solar cells. R. B. Godfrey and M. A. Green (New South Wales, University, Kensington, Australia). *Applied Physics Letters*, vol. 34, June 1, 1979, p. 790-793. 16 refs. Research supported by the Australian Research Grants Committee.

Major results are reported for silicon MIS solar cells. Open-circuit voltages up to 655 mV (AM0, 25 C) have been obtained for 0.1-ohm-cm silicon wafers, substantially higher than previously reported for any other silicon solar cell. On an active-area basis, the efficiency of these high-output-voltage cells is close to the best silicon cell yet produced, with 17.6% active-area efficiency (AM1, 28 C) for a 3-sq cm cell. (Author)

A79-37744 # Development of vertical-axis wind-energy converters - Darrieus design. A. Dekitsch, A. Fritzsche, W. Müller, and D. Welte. *Dornier-Post* (English Edition), no. 2, 1979, p. 28-30.

West German development of a wind energy converter is presented. Construction of the 5.5 m diameter Darrieus rotor using simple procedures is detailed, noting the Savonius start-up rotor mounted to the welded steel tube mast. Rotor characteristics of the system can be influenced by varying the number of blades of the Darrieus rotor and the height of the Savonius rotor. At the output stage, automobile generators can be used but their reduced efficiency makes their use undesirable despite their low cost. Highest output is obtained when the generator is adapted to the characteristics of the rotor. It is concluded that while application in the Federal Republic of Germany is unrealistic, development of a 20 kW turbine for the Argentinian coast, where wind conditions are more suitable, is under way. M.E.P.

A79-37774 A technological and economic study of the distribution of hydrogen for motor vehicles (Etude technico-économique de la distribution de l'hydrogène pour les véhicules automobiles). Y. Breille, C. Meyer (Institut Français du Pétrole, Rueil-Malmaison, Hauts-de-Seine, France), P. Gelin, and G. Petit (Commissariat à l'Energie Atomique, Gif-sur-Yvette, Essonne, France). *Revue de l'Energie*, vol. 30, Apr. 1979, p. 342-357. 30 refs. In French.

The technical and economic feasibility of storing and distributing hydrogen in liquid or gas form as a fuel for motor vehicles is analyzed, and two possible energy converters - the hydrogen motor and the hydrogen battery - are compared. It is concluded that at

present the distribution of gaseous hydrogen presents fewer technological difficulties than that of liquid hydrogen. The energy yield of hydrogen compares favorably with that of fuels synthesized from coal and with gasoline when used in a hydrogen battery. The cost of hydrogen used in a hydrogen motor ranges from two to four times that of present fuels (natural gas, gas oil, high-octane gasoline). The cost of hydrogen used with a hydrogen battery is about twice that of gas oil and natural gas. C.K.D.

A79-37842 International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. Conference sponsored by the Institution of Electrical Engineers. London, Institution of Electrical Engineers (IEE Conference Publication, No. 171), 1979. 460 p. \$46.

Papers are presented on solar energy utilization, wave power experiments, geothermal energy, tidal power, MHD power generation, wind energy systems, and hydrogen energy. Particular consideration is given to windpower generation on a large scale, the prospects of a biological-photochemical approach to the utilization of solar energy, tidal and river current energy systems, and satellite solar power stations. B.J.

A79-37843 Sputtered thin film solar cells. R. Hill, R. L. Wilson (Newcastle-upon-Tyne Polytechnic, Newcastle-upon-Tyne, England), R. Harrison, and G. Jenkins (Sunderland Polytechnic, Sunderland, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 17-20. 14 refs.

RF-sputtered films of CdS only 3 microns thick have been produced with characteristics suitable for efficient solar cells and the dry formation of the junctions has produced Cu₂S with a stoichiometry close to optimum. The contacts between the electrode materials and the semiconductor materials are nonrectifying and of low resistance. The interface between the CdS and Cu₂S seems to be the main cause of the present low efficiency of the completed cells, probably because the films are at present exposed to air between each process step. Improvements in the production procedure should enable sputtered cells to reach efficiencies of 4-6%. B.J.

A79-37844 Satellite solar power stations - Current status and prospects. P. O. Collins (Imperial College of Science and Technology, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 21-25. 28 refs.

A brief review of the satellite solar power station concept is presented with attention given to technical environmental aspects. Cost estimates are discussed and consideration is given to the possible use of extraterrestrial materials and to UK interest in the project. B.J.

A79-37845 The developing role of photovoltaic generation. P. R. Wolfe (Lucas Service Overseas, Ltd., Haddenham, Bucks., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 26-29. 21 refs.

The technology of existing and future solar photovoltaic devices is discussed with a view to the role which they will play and the applications for which they will be used. A cost-effectiveness analysis (taking into account savings offered in terms of reliability) is presented in an attempt to set limits of solar applications for various projects. B.J.

A79-37846 The development and construction of a simulator for the proof testing of solar power devices. J. R. Laidler and G. R. Bainbridge (Newcastle-upon-Tyne, University, Newcastle-upon-Tyne, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 30-35. 13 refs.

Variables affecting collector performance are reviewed and the discussion focuses on the different types of solar radiation distributions. This information is then used to examine the principles of solar simulator construction, with attention given to direct radiation simulation, diffuse radiation simulation, and environmental simulation. The solar simulator at the Energy Centre in the University of Newcastle-upon-Tyne is briefly discussed. B.J.

A79-37847 The significance of longwave radiation in flat plate solar collector testing. A. A. Green and W. B. Gillett (University College, Cardiff, Wales). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 36-39. 15 refs.

While it is evident that the longwave radiative flux incident on the front surface of a flat plate solar collector can vary significantly and that such variations affect collector performance, the problems involved in its measurement remain disproportionately large in relation to the small effect it has on outdoor collector test results for incident solar fluxes greater than 600 W/sq m. Methods of accommodating variations in longwave flux in collector testing are discussed and the concept of environment resulting temperature is shown to be of value for its ability to accommodate not only variations in incident longwave flux but also variations in solar flux absorbed by a front transparent cover. B.J.

A79-37848 Gallium arsenide solar cells. J. W. Burgess, R. Davis, and J. R. Knight (Plessey Research /Caswell/, Ltd., Allen Clark Research Centre, Towcester, Northants., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 40-43. 6 refs. Research supported by the Commission of the European Communities.

GaAs solar cells are discussed in terms of cell design, materials technology and device technology. Conversion efficiency of over 20% at 1000 suns has been reported for GaAs cells prepared by LPE. The figure for metal alkyl vapor phase epitaxial material is lower but is steadily approaching the liquid phase value. The incorporation in the cell of Ga(1-x)Al(x)As layer of graded composition leads to a marginal increase in efficiency together with the benefits of added stability under humid conditions and the likelihood of lower contact resistance. B.J.

A79-37849 A new approach for solar energy systems design by means of the sensitivity theory. G. Cammarata, A. Faro, A. Gallo, and F. Patané (Catania, Università, Catania, Italy). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 44-47. An algorithm is presented which uses a distributed parameter system model to solve the total sensitivity equation for a complete solar plant. This simulation method enables simultaneous observation in space and time of all sensitivity coefficients; this makes it possible to specify the nominal behavior of the system under variable conditions and to evaluate the optimal values of the mean efficiency of solar energy collection. B.J.

A79-37850 The prospects of a biological-photochemical approach for the utilization of solar energy. D. O. Hall (King's College, London, England) and J. Coombs (Tate and Lyle Research Laboratories, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 48-53. 5 refs.

A brief review is presented of the possibilities of developing energy conversion systems based on photosynthesis and photochemistry. Tables are presented giving cost and energy yield information for dry and wet biomass and attention is given to photochemical and photobiological processes for fuel-hydrogen and electricity. B.J.

A79-37851 Domestic space and water heating for existing dwellings using a heat pump and conventional roofs as energy absorbers. W. E. J. Neal and D. L. Loveday (Aston, University, Birmingham, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 57-60. 6 refs. Research supported by the Science Research Council.

A79-37852 Fossil fuel heat pumps for domestic, commercial and industrial space heating. R. E. Critoph (Open University, Milton Keynes, Buck., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 61-64.

It is noted that fossil fuel heat pumps are more efficient than electric ones. The present paper gives a description of the OUEG/Lucas gas-fueled heat pump, presents a schematic diagram and photographs of the device, and discusses predicted performances. B.J.

A79-37853 The problem of fouling in the utilisation of geothermal energy. T. R. Bott (Birmingham, University, Birmingham, England) and J. S. Gudmundsson (Orkustofnun, Reykjavik, Iceland). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 65-68. 12 refs. Research supported by the Science Research Council and Atomic Energy Research Establishment.

Problems associated with solids deposition and corrosion in geothermal waters are considered. Experimental work on deposition is reviewed and attention is given to some possible solutions to the deposition problem, including pretreatment of geothermal water, cleaning techniques, and alternative heat exchanger designs. It is concluded that the development of novel heat exchangers is imperative, the direct contact heat exchanger appearing to be the most likely development. B.J.

A79-37854 Performance estimation of a total energy domestic heat pump. W. G. Cartwright (University of Manchester Institute of Science and Technology, Manchester, England) and H. Fleming (Manchester Polytechnic, Manchester, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 69-72. 5 refs.

The performance of a variable speed, total energy heating system is estimated by synthesizing component data. The case considered is one in which a vapor compression heat pump makes the greatest possible contribution to the heat load. The variable speed capability enables a design point to be selected for a typical rather than an extreme ambient air temperature. This permits smaller components to be used at reduced capital cost. Extremes of temperature are accommodated by increased compressor speed at the expense of reduced coefficient of performance. It is estimated that the proposed heating system will consume about half the primary energy that would be used by a conventional domestic central heating system. B.J.

A79-37855 Heat pump application to single family dwellings - An analysis by computer model. J. Sundell and J. A. Bubenko (Kungl. Tekniska Hogskolan, Stockholm, Sweden). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 73-76.

A79-37856 Electro/mechanical aspects of the Mauritius 'passive' type wave energy project. A. N. W. Bott (Crown Agents, London, England). In: International Conference on Future Energy

Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 81-87.

A full scale research study into the possibility of harnessing seawave energy was initiated in the Indian Ocean island of Mauritius over 20 years ago. This paper focuses on electromechanical design proposals for the Mauritius system, with attention given to direct generation, indirect generation, pumping systems, and the hydraulic gas compressor. The desirability of attaining a 'firm' power output from a 'nonfirm' energy source, which in becalmed seas could be zero, is noted. B.J.

A79-37858 Directly driven generators for wave energy conversion. R. J. Jackson (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 92-95.

It is found that a directly driven ac generator applied in a wave energy conversion system (a linked pontoon pair wave energy converter) would have high losses (typically 11% of the generator output) and be much larger than the equivalent fixed speed machine. A directly driven homopolar generator would have relatively low losses, less than 5% of the mean power output, but the reversal of the rotor at the wave frequency necessitates the use of carbon brushes which would require regular maintenance. A smart generator which provides a variable reaction torque proportional to the displacement velocity and acceleration of the wave energy converter pontoons will be the same size and have about the same losses as the conventional generator which provides a fixed velocity proportional torque. B.J.

A79-37859 The absorption of energy from ocean waves. B. M. Count (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 96-99. 9 refs.

The paper examines the implications of linear wave theory for the optimization of the structure and power takeoff characteristics of wave power systems. Results are extended to accommodate realistic sea conditions and some unique engineering requirements are identified. Finally, the implications of nonoptimum mechanical conditioning are discussed along with areas where future development may be possible. B.J.

A79-37861 Wave power - Some practical considerations. I. Glendenning (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 109-113.

It is suggested that the overall economic viability of wave power devices depends as much on operational and maintenance considerations as on first costs. In this respect the best known and potentially the most attractive device, the duck, may be at a severe disadvantage when compared with less sophisticated devices. In addition, it is shown that the physical scale, peak power rating, and maximum continuous rating are independent variables in a complex optimization process for identifying the minimum energy production cost design. Finally, there is no short cut to the estimation of the energy produced by such devices. B.J.

A79-37862 Tidal and river current energy systems. P. L. Fraenkel (Intermediate Technology Development Group, Reading, Berks., England) and P. J. Musgrove (Reading University, Reading, Berks., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 114-117. 7 refs. Research supported by the Hilden Charitable Fund.

It is suggested that tidal streams and river currents provide a high density power source that could contribute significantly to the energy needs of many countries. Even large tidal stream power systems would have a modest development cost and could be speedily deployed in modular form as their economics warranted. Both for river currents and tidal streams, the vertical axis Darrieus rotor provides a simple means of harnessing the energy present, as has been demonstrated by a small scale experimental program. B.J.

A79-37863 Tidal power - The path to production. B. Severn and D. R. White. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 122-125.

The paper examines the perspective of tidal power studies which may lead to full project definition and firm decision whether to construct a selected project. The background and circumstances considered are primarily those of Severn Estuary and the UK for the mid-1978 period, though the underlying philosophy and much of the detail are of wider applicability. B.J.

A79-37864 System economic optimisation for wave energy. J. E. J. Cottrill (Department of Energy, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 126-129.

It is shown that the annual load factor of a wave energy scheme is a function of design rating expressed in kW/meter. As design rating is increased more energy can be extracted per meter of wave front, but annual load factor falls. The optimum load factor is shown to depend on the breakdown of costs of the components of the system but to be independent of absolute costs. A high load factor implies a low energy extraction per meter and hence an underutilization of equipment at the device end. A low load factor implies high ratings and hence an underutilization of equipment at the transmission end. B.J.

A79-37865 Influence of technological advances on potential tidal power development. R. Tanner, J. G. Warnock (Acres Consulting Services, Ltd., Canada), and D. Murphy (Fenco Consultants, Ltd., Toronto, Canada). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 130-142.

It is shown that tidal power development may benefit from several significant technological advances in the fields of civil, mechanical, and electrical engineering and proposed new energy storage and retiming methods. No single advance is likely to be overwhelming in economic impact and the necessary improvement in benefit/cost ratio for tidal power plants are likely to arise only from a well balanced application of a variety of new, existing, and future technologies. The scale of tidal power is usually large and the capital investment requirements very substantial. B.J.

A79-37866 Studies of tidal power from the Bay of Fundy. R. H. Clark (Environment Canada, Ottawa, Canada) and A. N. Karas (National Energy Board, Ottawa, Canada). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 143-151. 15 refs.

A79-37867 Marine structures for energy conversion. J. A. Derrington (Sir Robert McAlpine and Sons, Ltd., Luton, Beds., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 152-155. 6 refs.

It is found that the use of concrete caisson structures, floated into place ballasted down into the seabed or (alternatively) moored

in a permanent floating mode, for offshore energy conversion presents no major engineering problems. Their construction, durability, and the marine operations involved in their installation are well known. The recent development of concrete gravity structures for oil and gas production in the North Sea has shown that the method of construction inshore and integration of extensive mechanical and electrical equipment in sheltered waters before towing to their locations 100 miles or more offshore can offer an attractive alternative to offshore working. B.J.

A79-37868 Characteristics of a fully reversible axial pump-turbine for application in tidal power plants. M. Ravindran and H. C. Radha Krishna (Indian Institute of Technology, Madras, India). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 156-159. 8 refs.

A79-37869 The development of the wave contouring raft. W. J. Platts (Wavepower, Ltd., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 160-163.

Cockerell's wave contouring raft system involves chains of pontoons, hinged together so that the passage of a wave down the chain causes the pontoons to oscillate relative to one another; energy is extracted from the sea by applying a torque about the hinges to damp the motion. Wavepower Limited has been financed by the Department of Energy to examine the feasibility of the Cockerell raft for converting the energy of seawaves into electricity on a scale that would make a useful contribution to the UK's energy needs. The work has involved extensive model testing in wave tanks and the building and testing of 3-unit 1/10 scale power generating installation in the Solent, as well as design studies for a full size installation for Atlantic conditions. B.J.

A79-37870 Tidal current energy conversion. P. R. Wyman and C. J. Peachey (General Electric Co., Ltd., Hirst Research Centre, Wembley, Middx., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 164-166.

The paper considers a 'tide mill' concept involving extraction of energy from tidal currents by means of immersed rotors. The analogy with windmills can be drawn, with the difference that the tidal currents are predominantly bidirectional, so that an axial flow rotor which could accept reversal could be prealigned, and the cross flow rotor (Darrieus type) would lose one of its most important advantages. Tide mills are examined with reference to device design, generation and transmission, mooring and structures, and extent of available extractable energy. B.J.

A79-37871 Wave power experiments at Loch Ness. N. W. Bellamy (Lanchester Polytechnic, Coventry, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 167-169.

The duck wave energy generator was proposed by Salter in 1974 and subsequent work has established the device as a practical solution to the problem of extracting energy from seawaves. This paper discusses the engineering aspects of testing a 1/10th scale model of a Salter duck device on an inland water test site on Loch Ness in Scotland. Consideration is given to spine tests and duck string tests. B.J.

A79-37872 System reliability studies for wave energy generation. J. M. Dawson, M. G. Mytton (Rendel Palmer and Tritton, London, England), S. Din, N. L. Shore, and H. B. Stansfield (Kennedy and Donkin, Woking, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 170-176.

A first simplified approach to quantifying reliability for each stage of a wave power generation project is developed with particular application to United Kingdom conditions. The analysis is based on a notional scheme with floating devices generating power which is transmitted to platforms and thence to the shore. The basis of the model is that each component in the system always resides in either of two states: operative and failed. The system outcome (the power delivered via the inverter station) depends on the input power and the state of each of the components. Preliminary results are presented. B.J.

A79-37873 Batteries, fuel cells, a hydrogen economy
Keynote address. M. Barak. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 177-185. 28 refs.

Basic principles of batteries and fuel cells are considered and attention is given to common cells and batteries with aqueous electrolyte and properties of materials for cathodes and anodes. Attention is then given to the following types of cells, in the R&D stage or in pilot plant production: cells with lithium anodes, metal-air cells, metal-halogen cells, and high temperature batteries. The properties and applications of fuel cells are briefly reviewed and consideration is given to the possibilities of a hydrogen economy. B.J.

A79-37874 Hydrogen energy system concept and engineering applications. T. N. Veziroglu (Miami, University, Miami, Fla.). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 186-189. 7 refs.

The so-called hydrogen energy system is considered as a replacement for the fossil fuel system. In this system hydrogen is not a primary source of energy but rather an intermediary form of energy, and an energy carrier between the primary energy sources and the energy consuming sectors. Because of the advantages of hydrogen (high efficiency of conversion to other forms of energy, cleanliness, recyclability, etc.), research, development and demonstration projects are underway in order to determine the best engineering application of hydrogen to meet the needs of the energy consuming sectors. B.J.

A79-37875 Large scale energy storage - Batteries for transport and stationary applications. P. McGeehin (Atomic Energy Research Establishment, Marketing and Sales Dept., Harwell, Oxon, England) and J. Jensen (Department of Chemistry, Odense, Denmark). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 190-194. 7 refs. Research supported by the English Electric Co., and Department of Industry of England.

The paper examines the possible future use of storage batteries in both transport and stationary applications. The alternative systems which it is anticipated will offer direct competition are used as a yardstick to estimate how the future demand for batteries will vary with their cost. Advanced battery systems thought most likely to mature from R&D into the marketplace are reviewed briefly. B.J.

A79-37876 Compressed air storage. I. Glendenning (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 195-198. Research sponsored by the Electric Power Research Institute.

It is noted that compressed air storage (CAS) seems likely to be a realistic plant option for storage/intermediate duty applications in the relatively near future. Only site specific studies and the actual development of particular electricity generating systems will determine whether it is preferred to alternative storage, peaking or intermediate duty plant options. Where CAS is required in the near

future, cycles without thermal energy storage will be preferred but there are good incentives to develop low technology hybrids for later applications. In the long term as oil becomes scarce, CAS seems to be ideal for operation with gasification to fill the role of a low cost intermediate duty coal-fired plant. B.J.

A79-37878 Calcium hydroxide as an energy storage medium for solar power systems. C. Y. Wereko-Brobby and B. M. Gibbs (Leeds University, Leeds, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 207-210. 7 refs.

A combined power generating/storage scheme utilizing the heat of hydration of calcium oxide is proposed. The use of calcium oxide to store solar energy is particularly attractive because it has a high energy storage density and because the oxide can be stored for indefinite periods at ambient temperature. Analytical studies of the thermodynamics, reaction kinetics, and heat and mass transfer operation of the proposed scheme are presented and the results are discussed in terms of the feasibility and engineering design of the scheme. B.J.

A79-37879 Thermal energy storage using hot liquids. G. E. Clewer, A. Spurr (Central Electricity Generating Board, Marchwood Engineering Laboratories, Marchwood, Surrey, England), and B. J. Davidson (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 211-215. 16 refs.

Systems are proposed involving the storage under pressure of boiler feedwater or saturated water; a further option is transfer of heat to an oil store at atmospheric pressure. High stored energy/unit volume appears possible with feedwater storage but a high storage pressure is necessary in order to achieve a worthwhile power output gain. The use of oil as a storage medium may reduce storage costs to values comparable with high pressure underground stores. Saturated water storage using steam ahead of the main turbine control is thermodynamically less efficient than using turbine extraction steam but avoids the 'charging' mode problems. B.J.

A79-37881 High temperature batteries. I. W. Jones (Chloride Silent Power, Ltd., Runcorn, Ches., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 221-223. 12 refs.

The development of the sodium sulfur battery is briefly reviewed. Attention is given to cell design, sulfur electrode development (including current collection and sulfur electrode structure), sodium electrode development, seal development, and the ceramic electrolyte. B.J.

A79-37882 The use of non-fossil-derived hydrogen in coal conversion processes. D. Merrick and J. S. Harrison (Coal Research Establishment, Cheltenham, Glos., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 224-226. Research supported by the Commission of the European Communities.

The specific objectives of the present study are (1) to identify ways in which NFD (non-fossil derived) hydrogen can be used in the coal conversion process, (2) to analyze the implications of using NFD hydrogen in the design of the conversion processes, and (3) to assess the economics of using NFD hydrogen to produce synthetic hydrocarbon fuels. The study has been based on three reference processes: (1) gasification/synthesis for methanol production, (2) solid-phase hydrogenation for SNG production, and (3) liquid-phase hydrogenation for the manufacture of liquid fuels. In general the introduction of NFD hydrogen has the following effects: reduction

in the number of component processes; increased carbon utilization, resulting in a higher product yield per unit of coal input; and increased thermal efficiency. B.J.

A79-37883 Functional solar energy applications based on an improved insulation model. E. Aerts (Institut d'Aéronomie Spatiale de Belgique, Brussels, Belgium). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 232-235. 10 refs.

A79-37884 Some practical aspects of the design and installation of domestic solar energy systems in the UK. M. D. Powell (Aztec Solar, Ltd., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 236-239.

A79-37885 Solar electric generator for developing nations. C. G. Currin (Dow Corning Corp., Midland, Mich.). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 240-243. 10 refs.

A 50-watt solar generator, based on silicon solar cells, has been developed specifically for remote regions for a number of basic applications. The device has (1) simple design for reliable operation, (2) ease of installation, operation, and maintenance with common tools, and (3) potential for technology transfer, component fabrication and energy transfer in developing countries. The solar electric energy produced is found to be economically competitive with that from small gas engine or diesel engine generators in remote areas. B.J.

A79-37886 Complex static mirror solar concentration arrays. C. T. Mattingly. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 244-248.

A79-37887 Thin-film coatings in solar water heating systems. M. G. Hutchins (University College, Cardiff, Wales). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 249-252. 5 refs. Research supported by the Science Research Council.

The total hemispherical optical properties of a range of selective and nonselective solar absorber coatings were measured. No significant differences in these optical properties were observed among nonselective paints, which indicates that relative cost and durability will determine the choice of a nonselective matt black finish. The total hemispherical thermal emittance of the selective coating copper oxide increased significantly after one-year's use in a solar water heating system. No changes in optical properties were observed for the black chrome selective finish. B.J.

A79-37888 Solar heating and cooling systems - Practical experience in design and operation. D. J. Gilby and R. Minder. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 256-259.

Experience gained in the design and operation of a solar cooling test facility has been successfully applied in designing a large solar system. This installation will deliver part of the thermal energy required by an industrial plant located near Rome. The system, backed up by an oil fired boiler, will provide heating during the winter months, cooling during the summer months, and hot water during the whole year. B.J.

A79-37889 Performance and cost of domestic solar water heating in Australia. G. E. B. Smith (Victoria, State Electricity

Commission, Victoria, Australia) and D. Proctor (Commonwealth Scientific and Industrial Research Organization, Div. of Mechanical Engineering, Melbourne, Australia). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 260-263. 5 refs.

A79-37890 Large scale solar thermal power generation. B. McNelis (General Technology Systems, Ltd., Hounslow, Middx., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 264-267. 21 refs.

Solar power generation options are reviewed and particular consideration is given to the central receiver system. It is noted that a 100 MW plant in a sunny region would employ about 15,000 heliostats, each with an area of 35 sq m, a central tower about 260 m high, and would cover an area of about 1.2 sq km. The plant would operate for about 6-8 hours per day with a conversion efficiency of about 20%. B.J.

A79-37891 Windpower generation on a large scale. T. Mensforth. In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 268-272. 5 refs.

Some considerations on windpower generation are presented with reference to a 10 MW windmill. A general description of the windmill is given and attention is paid to rotor design. The influence of wind-height profiles is then discussed, taking into account wind thrust, economy due to size, optimal ground clearance, and accuracy of performance estimates. B.J.

A79-37892 Wind energy conversion and hydrogen production - A feasibility study for South Africa. R. G. Harley and E. Ben-Dov (Natal, University, Durban, Republic of South Africa). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 273-276. 9 refs.

A79-37893 The design construction and proving of a low cost 5kW wind powered turbine for isolated applications. G. R. Watson and G. R. Bainbridge (Newcastle-upon-Tyne, University, Newcastle-upon-Tyne, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 277-281. 7 refs.

A79-37894 A low cost wind energy conversion system for heating of domestic premises. L. L. Freris, H. Bolton, I. K. Buehring, and V. C. Nicodemou (Imperial College of Science and Technology, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 282-285. Research supported by the University of London and Science Research Council.

A79-37895 The aerodynamic design and testing of a vertical axis windmill. A. C. Willmer (British Aerospace, Aircraft Group, Bristol, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 286-289. 9 refs.

Wind tunnel tests were conducted in order to refine a mathematical model for the design of large vertical axis windmills. The mathematical model uses an induced velocity factor derived from the test data. This factor was derived by a relaxation process in which the calculated cross arm and blade loads were made to agree with the measurements by adjusting the induced velocity factor. B.J.

A79-37896 Directional arrays of windmills. D. T. Swift-Hook and R. H. Taylor (Central Electricity Generating Board, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 290-293. 6 refs.

Directional wind energy data are examined and consideration is given to array limitations, and to isotropic, anisotropic, and rectangular arrays. Directional arrays appear to have considerable advantages over isotropic arrays with respect to energy density (perhaps 2.7 times) and power density (perhaps 4 times). Their main disadvantage (a generation cost penalty of 50% or more) may be offset by reduced power marshalling and transmission costs. B.J.

A79-37897 Materials for windmill blades. P. J. Worthington (Central Electricity Generating Board, Research Laboratories, Leatherhead, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 294-297.

Consideration is given to material property requirements and blade design for large windmills capable of generating more than 1 MW of power. It is concluded that composite materials (carbon/epoxy, glass/epoxy, boron/epoxy, and Kevlar/epoxy) offer a number of attractions as windmill blade materials. Titanium alloy also has some attractive properties. A combination of materials for windmill blade construction may turn out to be the optimum choice. B.J.

A79-37898 Prediction and measurement of aerogenerator performance. D. T. Swift-Hook, A. J. Blackburn, D. J. Milborrow, R. H. Taylor (Central Electricity Generating Board, London, England), H. Lawson-Tancred, and W. R. Nickols (Sir Henry Lawson-Tancred, Sons and Co., Ltd., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 298-301. 10 refs.

The results of some preliminary field measurements made on the 30 kW windmill at Aldborough in March 1978. Measurements of performance coefficient vs. tip/air speed ratio were broadly in line with the predictions of fan theory. Direct measurements of the small velocity deficits in the wake produced by the machine proved difficult because of natural turbulence levels. B.J.

A79-37899 Depletion of available wind power by a large network of wind generators. D. J. Moore (Central Electricity Generating Board, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 302-305.

The greater surface drag associated with a large matrix of wind generators will modify the velocity profile in the mixing layer and reduce the wind speed at generator level. Calculations indicate that if more than 80 percent of the available power output is required, such a network should be restricted to rated outputs of less than 1 MW/sq km. Greater power densities at high efficiency (up to 20 MW/sq km) can be achieved with arrays with a few (three to six) rows of generators orientated normal to the prevailing strong wind direction. The options for varying the principal network parameters are shown to be limited. (Author)

A79-37900 The design and construction of the Aldborough aerogenerator. W. R. Nickols (Sir Henry Lawson-Tancred, Sons and Co., Ltd., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 306-308.

The Aldborough horizontal axis windmill is the largest aerogenerator operating in the UK. This paper presents a review of the

construction (blades, drive, and generator) and operation of the machine. Certain improvements in the basic design are considered. B.J.

A79-37901 Offshore wind energy systems for the U.K. P. J. Musgrove (Reading, University, Reading, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 309-312. 16 refs.

Some of the more important factors affecting the design of offshore wind energy systems are discussed. It is shown that power densities in offshore winds are attractively high, of the order of 300 kW/linear meter (perpendicular to the wind direction). The economics of offshore operation strongly favors the use of large wind turbines (about 100 m diameter) and a low rated wind speed is also advantageous. A typical offshore wind energy system might comprise a 10 x 10 array of 100 m diameter wind turbines to give a cluster rating of 600 MW and a plant factor of about 40%. B.J.

A79-37902 Wind power for domestic use in the United Kingdom. J. G. F. Littler and R. B. Thomas (Cambridge University, Cambridge, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 313-316. 14 refs.

The paper stems from the work of the Cambridge Autarkic Housing Project on the servicing of dwellings with little or no network energy. In the area of wind energy the Project has concentrated on the provision of 240 V, 50 Hz domestic supplies. The wind turbine to be used at Cambridge is described and attention is given to the approach used in optimizing the division of expenditure on thermal storage and wind turbine size when considering the use of wind power for space and water heating. B.J.

A79-37903 Fluid bed combustion coal fired steam locomotive. J. E. Sharpe (Queen Mary College, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 325-329.

The paper examines the basic requirements and constraints of any future design of a coal-burning locomotive and discusses the merits of using fluidized bed combustion. Attention is given to a proposed Rankine cycle for a freight locomotive, with emphasis on some control problems associated with the complex dynamically interacting thermodynamic components. It is concluded that a steam locomotive can be built that would have as good power-to-weight and power-to-volume ratios as the present generation diesel-electric locomotives and better overall thermal efficiency. B.J.

A79-37904 Open cycle MHD generation in the United Kingdom - A reappraisal. D. B. Meadowcroft, D. T. Swift-Hook, and B. A. Tozer (Central Electricity Generating Board, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 330-333.

It is shown that in the UK there will be a continuing need for fossil-fired generation for part-load and that MHD is one of the competing technologies aimed at giving increased efficiencies and reduced generation costs for such a plant. Because of the limited building program required before 2000 it is difficult to justify a large research program on any of the options at this stage; except for duct materials, MHD development has reached the stage where expensive large scale engineering programs are needed. One sensible strategy could be to maintain a low level effort in the UK over the next few years to keep in touch with developments with a view to expanding if necessary as the situation becomes clearer and the uncertainties less. B.J.

A79-37905 Aspects of meeting complex industrial energy demand patterns using recuperated gas turbines. J. R. A. Lowder (GEC Power Engineering, Ltd., Whetstone, Leics., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 334-344.

The paper shows how recuperated gas turbines in conjunction with appropriate control strategies are able to accommodate a wider variation of power demand patterns without involving excessive heat topping or dumping. Three distinct configurations of combined heat and power (CHP) plant and associated control are identified, with the optimum depending on details of the annual distribution of heat and power requirement. A thermodynamic analysis of the proposed systems is given and supported by the results of a computer simulation based on the measured energy profile of an industrial site where the heat to power ratio was observed to vary from 0.5 to 11.5 throughout the year. Energy and cost savings are presented for the three configurations and some practical engineering aspects are discussed. B.J.

A79-37906 The potential application of rotating fluidized beds to power generating schemes. B. M. Gibbs (Leeds University, Leeds, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 350-354.

The application of rotating fluidized beds to direct fire turbines is found to result in a combustor/gasifier size which is substantially smaller than that possible using conventional pressurized fluidized beds. The combustion intensities and turn-down rates achieved by using rotating fluidized beds are comparable to those being used at present in conventional gas turbine combustors. The rotating fluidized bed combustor/gasifier is equally suitable for use in a combined gas-steam cycle. There are a number of engineering problems which have to be overcome before rotating fluidized beds can be considered as viable alternatives to conventional fluidized beds. B.J.

A79-37907 Prospects of MHD power generation in India using coal. V. R. Ramaprasad, V. R. Malghan, and K. Ravi Kumar (Bharat Heavy Electricals, Ltd., Madras, India). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 358-361. 9 refs.

The paper briefly reviews the Indian coal-based MHD power generation program. Program planning includes studies of plasma properties and plasma dynamics; development and testing of high temperature materials; testing of MHD components and subsystems; and investigation of the technical and economic aspects of MHD power cycles. B.J.

A79-37908 Combustion of low grade fuels in fluidized beds. E. A. Rogers, A. J. Minchener and R. D. La Nauze (Coal Research Establishment, Cheltenham, Glos., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 362-365. 6 refs. Research supported by the European Economic Community and European Coal and Steel Community.

Test work conducted in the United Kingdom has demonstrated that fluidized bed combustion can provide a satisfactory and flexible means of burning a range of low grade fuels (including coal processing wastes, naturally occurring carbonaceous materials of low calorific value, municipal refuse, sewage sludge, and industrial wastes). Emissions of oxides of sulfur and nitrogen can be controlled to acceptable levels while fuels with high ash or moisture which cannot be burned by conventional means can be handled by the fluidized bed combustion process. B.J.

A79-37909 Fluidised combustion for power generation. H. R. Hoy and A. G. Roberts (National Coal Board, Coal Utilisation Research Laboratory, Leatherhead, Surrey, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 370-373.

The paper outlines current developments in the field of fluidized bed combustion for power generation, giving attention to the choice of fluidized combustion systems, the development of pressurized fluidized combustion, and the design of combined cycle power plants (both supercharged boiler combined cycle and air heater combined cycle plants). Further developments needed to bring these schemes to fruition are discussed with emphasis on hot gas clean-up and start-up and control. B.J.

A79-37910 The Grimethorpe Experimental Pressurised Fluidised Bed Combustor. D. H. Broadbent (International Energy Agency Services, Ltd., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 374-378.

The Grimethorpe experimental combustor is surveyed with attention given to the combustor design and operation, the process, the steam water circuit, the fuel system, ash removal, the water treatment plant, and plant control. Cross sections of the 75 MW(TH) combustor and of the heat exchanger are presented along with the gas/solids flow sheet. B.J.

A79-37911 Electricity from municipal wastes. A. W. Carter (Resources Recovery Board, Jersey, Channel Islands, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 379, 380.

Production of electricity from digested sewage sludge and from municipal solid waste is discussed. The future potential of such systems in the United Kingdom is examined and the economics of the matter is briefly considered. B.J.

A79-37912 Use of low grade fuel derived from domestic and trade wastes. J. D. Tottman, K. Tittle (Central Electricity Generating Board, North Western Region, England), and B. Jones (General Engineering Co., Ltd., Radcliffe, Lancs., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 381-384.

Tests have been performed in order to evaluate the possible use of fuels derived from domestic and industrial waste as supplementary fuels for firing in moving grate boilers. Mixtures of coal and EPR (enriched processed refuse, a low grade fuel produced from a mixture of domestic refuse and oil waste) have been fired in the boilers at Kearsley 'B' Power Station. Results of boiler efficiency tests indicate that a mixed fuel containing 40 wt% EPR would be burned with a minimal loss in boiler efficiency and with a slight drop in boiler load. B.J.

A79-37913 The integration of a complex of wind-driven generators into a power system. E. D. Farmer, V. G. Newman, and P. H. Ashmore (Central Electricity Generating Board, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings.

London, Institution of Electrical Engineers, 1979, p. 385-389. 5 refs.

A79-37914 Options and constraints in the use of wave power. D. S. McIlhagger (Belfast, Queen's University, Belfast, Northern Ireland). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 390-393.

Various aspects of wave energy conversion are reviewed with attention given to the storage of wave energy (taking into account cyclic, intermittent, and seasonal variations) and the compatibility of

manufacturing processes with wave power supply. Modes of wave power transmission (including hydraulic, pneumatic, thermal, and chemical) are discussed along with modes of generation, transmission, and utilization of electric power obtained from the waves. B.J.

A79-37915 **Electrical generation from a randomly varying input.** H. W. Whittington and D. S. Wilson (Edinburgh, University, Edinburgh, Scotland). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 402-405.

An asynchronous electric generation system based on induction generators feeding a common bus bar with local provision of quadrature current was developed for sea wave power extraction, where the randomly varying input makes conventional synchronous extraction not viable. A synchronous machine operates as a local compensator, providing the magnetizing current requirements of the induction generators and drawing its own windage and friction losses from the induction generators. A 1/200 scale version of the system was built and tested with the synchronous machine set with (1) a resistive load, and (2) a diode load. Ranges of stable operation were determined. P.T.H.

A79-37916 **Initial thoughts on the transmission implications of large wave power complexes.** R. P. Mayes and E. M. Eunson (Central Electricity Generating Board, London, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 406-413.

The paper summarizes a study carried out to assess the technical problems and costs associated with connecting groups of wave power facilities to the national electrical grid of Great Britain. The wave power abstraction rate was taken as 60 kW/m and consideration was given to (1) a 600 MW group located 20 km off-shore, which is 12 km long; (2) twenty 600-MW groups 10-40 km off the Outer Hebrides and the west coast of Scotland over an arc of 350 km; and (3) three groups off the Hebrides, Berwick, and Lundy Isle, each 4 GW. Sensitivities and proportion of costs due to geographical locations are discussed in terms of total capacities and the off-shore and on-shore connection costs. A sample of some of the conclusions shows that there is no economy of scale for transmission costs with a 12 GW concentration of wave power generation off the Hebrides. Three distributed 4 GW sites would show a saving of 66% and a single 2 GW group of Berwick would give a 92% saving in terms of specific costs. P.T.H.

A79-37917 **Load matching effects on wind energy converter performance.** J. C. Dixon (Open University, Milton Keynes, Bucks., England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 418-421.

A79-37918 **Energy analysis of wave and tidal power.** R. Harrison, K. G. Smith, and J. S. Varley (Sunderland Polytechnic, Sunderland, England). In: International Conference on Future Energy Concepts, London, England, January 30-February 1, 1979, Proceedings. London, Institution of Electrical Engineers, 1979, p. 422-426. 12 refs.

A methodology is developed for energy analysis of wave and tidal power based on the concepts of energy ratio defined as total output over lifetime of device divided by energy required to build the device or the output of the device over one year divided by energy requirements for one year's operation, and extraction efficiency, defined as total output of device over a season divided by total energy incident on the devices at that location. When applied to the Salter duck, the energy ratio analysis gives a figure of 13.1 for a duck made of concrete, which implies viability, but a ratio of 10.1 for a steel duck, which is probably not viable. For a Shaw two-basin tidal power system, it is clear that the energy requirement of

construction will be a significant fraction of the barrage output, and that further work on energy analysis is justified. P.T.H.

A79-38040 # **Development and testing of two- and three-stage heat pipe radiators.** D. E. Wilson and J. P. Wright (Rockwell International Corp., Satellite Systems Div., Downey, Calif.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, Paper 79-1060.* 6 p. 5 refs.

The work summarized in this paper proves the concept of employing heat pipes and staged radiators to achieve passive cooling at cryogenic temperatures substantially lower than would have been considered possible even a few years ago. The multistage radiator concept presented offers a unique approach to the problem of rejecting large heat loads at very low temperatures. Perhaps the most significant feature of the multistage radiator system is that great improvements in insulation technology are not required to reach temperatures of 40 K and lower. During 1978, two- and three-stage radiators were designed, optimized, fabricated, and thermally tested. An oxygen heat pipe was bonded to the second stage to transport heat to the radiator from a simulated low-temperature heat source. The two-stage radiator demonstrated passive cooling to 71.6 K with 0.8 W applied and achieved a temperature of 51.5 K with no load. The three-stage configuration rejected 30 mW at 40.5 K and achieved 33.5 K with no load. Correlations between the test results and analytical predictions based on a nodal thermal network are presented. Results show excellent agreement with test predictions. (Author)

A79-38041 # **Flight performance evaluation of heat pipe solar collector in a spin environment.** H. Hwangbo (MRJ, Inc., McLean, Va.) and J. H. Hunter (Fairchild Space and Electronics Co., Germantown, Md.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, Paper 79-1061.* 6 p.

Flight-performance evaluation of a spinning heat pipe/solar collector assembly is described. The heat pipes rotate radially about a spacecraft spin axis and transfer heat from an external solar collector panel to an internal equipment deck. This paper presents details of an analytical thermal model which predicts performance at various sun angles and during transition into earth shadow. Flight-temperature data are used in this performance evaluation as evidence that the heat pipes operated efficiently in a spin environment. A sensitivity study of the design parameters revealed that the IR emittance of the solar-collector surface was by far the most influential in determining the overall efficiency of the heat pipe/collector composite. Variations of conductance couplings within the composite had very little effect on efficiency. (Author)

A79-38045 # **Thermal contact conductance of flat plate solar collector materials.** R. R. Somers, II, L. S. Fletcher (Virginia, University, Charlottesville, Va.), J. W. Miller, and R. H. McCafferty. *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, Paper 79-1066.* 5 p. 6 refs.

This paper describes an experimental program in which the thermal contact conductance of aluminum/copper interfaces in vacuo was determined for contact pressures ranging from 0.07 to 9.1 MN/sq m and for junction temperatures of 50 to 175 C. Tests have been conducted for both bare metal contacts and for contacts in which silicone grease of high thermal conductivity was applied to the interface to improve the heat transfer at the joint. The experimental results indicate that the thermal contact conductance between the aluminum and copper is increased significantly when the grease is used. The introduction of grease between the fin and tubing of a flat-plate solar collector may improve the heat-transfer efficiency of the collector substantially. The data will enable designers to estimate the increase in collector efficiency that results when silicone grease is used at the fin-tube bond and to determine if the use of interstitial greases in aluminum/copper collector assemblies is desirable economically. (Author)

A79-38060 # Externally pumped Rankine cycle thermal transport devices. R. J. Hannemann (Digital Equipment Corp., Maynard, Mass.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, Paper 79-1091.* 7 p. 10 refs.

An attempt is made to document a brief feasibility study of the use of externally pumped heat pipes (EPHPs) for the thermal control of large structures in space. The discussion is limited to a simplified EPHP analysis, idealized performance for space structure isothermalization, and potential terrestrial applications. If the source and sink have finite thermal capacities, the EPHP will tend to equalize their temperatures, which is the desired goal for eliminating thermal stresses in large structures. The EPHP offers significantly improved thermal performance if one is willing to pay the price of supplying a small amount of pumping power. Terrestrial uses, such as thermal transport in solar energy systems or electronic equipment cooling, are potentially even more significant than space application. S.D.

A79-38101 The change in the interface-state Fermi level of MIS solar cells when going from dark to illuminated conditions. O. M. Nielson (Danmarks Tekniske Højskole, Lyngby, Denmark). *IEEE Journal on Solid-State and Electron Devices*, vol. 3, May 1979, p. 57-60. 9 refs.

Current/voltage characteristics obtained under dark and illuminated conditions have been examined for Al-p-Si MIS solar cells. The results show that the voltage drop across the oxide is changed, owing to the increased surface concentration of minority carriers when going from dark to illuminated conditions. The inverse slopes n of the linear region have been measured and the interface-state densities have been calculated. From the voltage changes and interface state densities obtained, the changes in the interface-state Fermi levels have been calculated to be about 0.05-0.1 eV for short-circuit currents of 25-30 mA/sq cm. (Author)

A79-38174 # Low cost Darrieus vertical-axis wind turbine design. D. K. Ai (Alcoa Laboratories, Alcoa Center, Pa.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0966.* 10 p. 12 refs. Research sponsored by the U.S. Department of Energy.

The main objective of a low cost Darrieus type wind turbine design effort carried out for the U.S. Department of Energy is to obtain realistic fabrication cost data based on current technology. An existing 17 m Sandia research turbine served as a background machine for development of the Low Cost design. Different design aspects of the 17 m Low Cost turbine are studied including the rotor and its support, the drive train which incorporates a motor-generator for start-up, and the controller. The Low Cost design proved to be 30% lighter, 27,000 lb versus 37,000 lb, while 50% more powerful than the original background turbine. The average cost per unit and the energy cost based on a production quantity of 100 units per year is computed as a function of wind site and annualized ownership and maintenance costs. At a typical site with an annual mean wind speed of 15 mph, the energy cost falls into the range of 3-6 cents/kWh.

M.E.P.

A79-38175 # Tilting wing overspeed control for vertical axis wind turbines. J. L. Loth (West Virginia University, Morgantown, W. Va.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0967.* 5 p.

The design criteria are presented for a simple, reliable overspeed control for small vertical axis wind turbines. A bearing in the radial support arm, attached to the middle of the blades, permits them to tilt forward to take on a swept wing configuration when the turbine reaches a preset speed. In the tilted position the mass of the blades near the tip has a larger radius of gyration and this generates the tilting moment of the blade when the turbine rotates. The tilt restraining force required is a small fraction of the centrifugal force acting on the blades. (Author)

A79-38176 # Analytical and experimental evaluation of Cycloturbine aerodynamic performance. N. D. Ham (MIT, Cambridge, Mass.), P. Soohoo, R. B. Noll (Aerospace Systems, Inc., Burlington, Mass.), and H. M. Drees (Pinson Energy Corp., Marston Mills, Mass.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0968.* 7 p. 10 refs. Research supported by the U.S. Department of Energy.

The aerodynamic performance of a Cycloturbine is discussed. The Cycloturbine is a vertical-axis, straightbladed, wind-driven turbine with three cyclically pitched blades. Due to its unique configuration, aerodynamic performance models used for classical horizontal-axis wind machines and for the vertical-axis Darrieus wind machines are not applicable. Therefore, an analytical model was formulated for the Cycloturbine aerodynamic performance and had been programmed for computer calculation. Both the mathematical model and the computer program CAPE (Cycloturbine Aerodynamic Performance Evaluation) are discussed. The analysis had been compared with experimental data generated by a natural-wind test program using an instrumented prototype Cycloturbine. The comparison indicates that the computerized analytical model can accurately predict the performance of the machine. (Author)

A79-38177 # Prediction of stresses and natural frequencies for high speed wind turbine blades. F. Perkins (Solar Energy Research Institute, Golden, Colo.) and D. Cromack (Massachusetts University, Amherst, Mass.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0970.* 6 p. Research supported by the U.S. Department of Energy.

The static and dynamic characteristics of a wind turbine blade were predicted and measured. The differential equations of bending allowing coupling between bending in two planes were solved. The response of a twisted, tapered and nonhomogeneous wind turbine blade to a point load was determined by measurements of deflection, the radial bending stress distributions and the chordwise stress distribution. The determination of the blade natural frequencies allowed two degrees of freedom at each station. Good agreement between predicted and observed stress values was observed. The determination of the natural frequency showed that the fundamental flexural mode shape had both an in-plane and out-of-plane component at the tip. Torsional coupling was probably not important for this blade. Good agreement between observed and predicted natural frequencies was also observed. (Author)

A79-38178 # The use of a complex-terrain wind model for the siting and design of wind generators. M. A. Yocke, J. Johnson, and M.-K. Liu (Systems Applications, Inc., San Rafael, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0971.* 7 p.

The questions arising when wind power is under consideration for the generation of electricity, such as how much annual wind energy can be expected and how the wind is distributed, are discussed showing the need for a knowledge of wind speeds and directions. A wind model based on the three-dimensional mass continuity equation, with the appropriate physical processes parameterized is analyzed. Derivation of the equation is given, noting that the model considers perturbations such as dimensions of the flow due to topographic effects, and power law wind profile due to boundary effects. The model's performance was assessed by applying it to Phoenix, Arizona and Los Angeles, California. M.E.P.

A79-38179 # Testing and evaluation methods to determine an optimal air-flow rate in flat-plate solar collectors. H. C. Hewitt, Jr. and E. I. Griggs (Tennessee Technological University, Cookeville, Tenn.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0972.* 7 p. 8 refs.

The paper presents a testing procedure, using identical side-by-side, flat-plate solar air collectors, for determining some of the most

important parameters, such as energy demand, storage capacity, and cost, in collector performance. The equation used for the analytical model is derived from the Hottel-Whillier-Bliss equation. A section devoted to the experimental program, discusses the system test apparatus, which allowed simultaneous testing by directing air between the glass cover and absorber plate or between the absorber plate and the back insulation. Performance data from this test are given and an economic analysis calculating lifetime cost of a collector system is made. Among the conclusions are that when the electrical cost increases, the optimal mass flow rate decreases, and that when the initial cost increases, the mass flow rate increases. The optimal flow rate at 8 cents/kW-hr was between 2 and 3 cfm/sq ft. At 2 cents/kW-hr the optimal flow was between 4 and 5 cfm/sq ft. M.E.P.

A79-38180 # Domestic hot water heating using hot air solar collectors. J. L. Loth (West Virginia University, Morgantown, W. Va.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0973.* 6 p. Research supported by the U.S. Department of Energy.

The utility period of a hot-air solar home heating system can be extended by utilizing the hot air collectors in the summer time for domestic hot water heating. This requires the addition of heat exchangers to transfer the heat from air to water. Such a hybrid system operates at a significantly reduced overall efficiency. A graphical solution has been derived for the efficiency of the hybrid system as a function of the area ratio between the solar collectors and that of the heat exchanger fins. Air to water heat exchangers made from air conditioning evaporator coils have been tested on the WVU solar air heater system. (Author)

A79-38181 # Solar collector sizing and design - An overview. J. R. Howell (Texas, University, Austin, Tex.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0975.* 8 p. 8 refs.

A method for predicting the performance of flat-plate solar energy collectors is presented. The derivation is based on the assumptions of the Hottel-Whillier-Bliss method (1958; 1959); however, the present approach is more closely related to conventional heat transfer analysis. The local and overall energy gain of the collector are found in terms of the inlet fluid temperature. The modified approach gives results directly comparable to those obtained by the effectiveness-number of transfer units method, and are in acceptable agreement with experiment. The efficiency and cost ratio curves of five collector types are given and their use in selecting a collector for a given application is discussed. C.K.D.

A79-38182 # Thermal performance of integrated solar collector evaporator heat pump. S. K. Chaturvedi (Old Dominion University, Norfolk, Va.) and V. Mei (Illinois Institute of Technology, Chicago, Ill.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0976.* 7 p.

A simplified method for prediction of thermal performance of a solar assisted bare collector evaporator heat pump is used for various ambient conditions, working fluids, and collector designs. The characteristics of bare collectors as heat pump evaporators are discussed and the thermal analysis of heat pump parameters presented. The evaporator temperature is predicted for various ambient parameters such as wind speed, solar radiation and ambient temperature for two different collector designs and two working fluids, Freon-22 and Freon-12. The results show that evaporator temperatures 10 to 20°C above ambient temperature can be maintained for wide ranging ambient conditions, which will result in much improved thermal performance of the heat pump. The use of cheaper bare collectors should considerably lower the overall cost of the pump system. A.T.

A79-38183 * # Study on the application of NASA energy management techniques for control of a terrestrial solar water

heating system. T. D. Swanson (Mueller Associates, Inc., Baltimore, Md.) and S. Ollendorf (NASA, Goddard Space Flight Center, Greenbelt, Md.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0977.* 10 p. 15 refs. NASA-supported research.

This paper addresses the potential for enhanced solar system performance through sophisticated control of the collector loop flow rate. Computer simulations utilizing the TRNSYS solar energy program were performed to study the relative effect on system performance of eight specific control algorithms. Six of these control algorithms are of the proportional type: two are concave exponentials, two are simple linear functions, and two are convex exponentials. These six functions are typical of what might be expected from future, more advanced, controllers. The other two algorithms are of the on/off type and are thus typical of existing control devices. Results of extensive computer simulations utilizing actual weather data indicate that proportional control does not significantly improve system performance. However, it is shown that thermal stratification in the liquid storage tank may significantly improve performance. (Author)

A79-38184 * # Thermal and other tests of photovoltaic modules performed in natural sunlight. J. W. Stultz (California Institute of Technology, Jet Propulsion Laboratory, Applied Mechanics Div., Pasadena, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0980.* 15 p. 6 refs. Research sponsored by the U.S. Department of Energy.

The nominal operating cell temperature (NOCT), an effective way to characterize the thermal performance of a photovoltaic module in natural sunlight, is developed. NOCT measurements for more than twenty different modules are presented. Changes in NOCT reflect changes in module design, residential roof mounting, and dirt accumulation. Other test results show that electrical performance is improved by cooling modules with water and by use of a phase change wax. Electrical degradation resulting from the marriage of photovoltaic and solar water heating modules is demonstrated. Cost-effectiveness of each of these techniques is evaluated. (Author)

A79-38185 # A method to increase the efficiency of solar photovoltaic devices by secondary emission. T. Morgan (United Technologies Corp., Chemical Systems Div., Sunnyvale, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0981.* 5 p. 7 refs.

To increase the efficiency of solar photovoltaic cells it is necessary to eliminate two major sources of loss, the thermal agitation of the cell lattice and the solar spectral frequency cutoff. By splitting the incoming radiation that is below the characteristic cell threshold from the incident light, and concentrating it to heat an emitting gas which has a spectral component greater than the band energy of the cell some of the lost solar energy may be regained in the form of the secondary emission. Various noble and organic emitters are analyzed and sample theoretical efficiency gains are calculated. (Author)

A79-38186 # Power management battery storage systems. O. P. Hall, Jr. (TRW, Inc., Energy Systems Group, Redondo Beach, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0982.* 9 p. 6 refs.

The technical and economic aspects of an integrated electric power management system with battery storage, intended to reduce dramatically electricity costs by reducing peak power demands, are discussed and a candidate design for such a system is presented. The system consists of a storage battery connected to an AC line current by a power processor, which acts as both a rectifier and an inverter. An energy management computer receives status information from various segments of the system, controls the charging and discharging of the battery and selects the loads to be shed by the user during peak demand periods. System component specifications for a 1.1

MWh demonstration design with a load capability of 600 kW to service a facility with short, relatively high daytime peaks are presented. Total energy savings from the demonstration power management system are calculated to result in a payback period of 18 months. Projections indicate a possible savings of 1 million barrels of oil per day by the middle 1980's if power management systems with battery storage were widely implemented. A.L.W.

A79-38187 # Selected results from the technology assessment of solar energy program. M. C. Krupka and J. H. Altseimer (California University, Los Alamos, N. Mex.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0984*. 9 p. 21 refs. Research sponsored by the U.S. Department of Energy.

Selected results on the environmental, institutional and social impacts of the large-scale deployment of decentralized solar technologies obtained by the Technology Assessment of Solar Energy program of the Department of Energy are presented. The first phase of the program is almost complete and consisted of characterizing different solar technologies and quantifying the indirect residuals of solar energy acquisition. A second phase will assess selected environmental, social, health and safety aspects of solar technology utilization. Study results for a model residential photovoltaic system are presented as an example. While the operating environmental impacts of solar technologies are considered to be small, with the possible exception of residuals derived from a battery energy storage subsystem, indirect impacts may be considerable. For a photovoltaic silicon solar cell technology, solar cell fabrication and metallurgical grade silicon production technologies have been found to cause extensive pollution in some cases. A.L.W.

A79-38188 # Progress on high temperature air heater development for MHD systems. L. R. White, D. G. DeCoursin (FluidDyne Engineering Corp., Minneapolis, Minn.), and A. W. Postlethwaite (U.S. Department of Energy, Washington, D.C.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1003*. 8 p. 19 refs.

Progress in the development of regenerative air heaters for directly- and indirectly-fired MHD systems is reviewed. For directly-fired heaters, major developmental problems are associated with the corrosion of refractories and the deposition of seed or slag. Simulations of MHD gas heating and air cooling cycles have shown that dense, low porosity materials are needed to withstand corrosion, and a fusion cast structure of magnesia grains imbedded in a magnesia/alumina spinel matrix is being investigated. Testing of a small-scale simulated heater has revealed the conditions under which seed deposition can be prevented. The developmental needs of separately-fired heaters depend on whether the fuel burned is clean or dirty. Work is in progress on slag deposition in heater passages and refractory corrosion due to slag attack in heaters fueled with dirty fuel. If a clean fuel is burned, current hot blast stove technology can be utilized at air temperatures up to 1644 K, however development of materials for higher temperatures is needed. Valves for MHD heaters are also under investigation. A.L.W.

A79-38189 # Fully developed laminar heat transfer in passages of triangular cross section for application to solar collector plate design. G. E. Schneider (Waterloo, University, Waterloo, Ontario, Canada) and B. L. LeDain. *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0974*. 9 p. 16 refs. Research supported by the Natural Sciences and Engineering Research Council of Canada.

The problem of determining the Nusselt number for fully developed, laminar flow in a duct of triangular cross-section has been addressed. The particular application to solar plate design is considered for which the collector plate forms heat transfer passages of triangular cross section. The cases for which the heat transfer occurs over all three surfaces and for which the back surface is insulated are both addressed. The two boundary conditions of a

uniform peripheral flux and a uniform peripheral temperature are examined for the case of uniform axial heating rate while the uniform peripheral temperature boundary condition is examined for the case of a uniform axial temperature specification. Solutions are obtained using the finite element method to solve the momentum and energy conservation equations. Numerical results are presented over the entire range of corner half-angle. (Author)

A79-38190 # Solar energy storage using reversible hydration-dehydration of CaO-Ca(OH)_2 . J. K. Rosemary, G. L. Bauerle, and T. H. Springer (Rockwell International Corp., Energy Systems Group, Canoga Park, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0986*. 6 p.

Studies of solar energy storage by the reversible hydration of CaO-Ca(OH)_2 are presented. The properties of CaO-Ca(OH)_2 were investigated under conditions typical of a fixed-bed reactor, in which heat required to dehydrate the salt is carried to it by a heat transfer fluid, and heat generated by the reverse reaction is carried away by the same fluid. In cycling tests of the apparatus (up to 1171 cycles) reaction rates were not observed to change drastically, however evidence of corrosion and air leakage was found. For the hydration reaction, the heat of reaction, equilibrium constants, activation energy and reaction mechanism data were determined by a pressure differential scanning calorimeter. System application studies relative to a commercial solar power plant show that a fluidized bed CaO-Ca(OH)_2 concept is most cost effective for storage times of 16 h or more, while a high temperature sensible heat system provides slightly lower costs than thermochemical CaO-Ca(OH)_2 storage systems for storage times up to 14 h. A.L.W.

A79-38191 * # Redox flow cell energy storage systems. L. H. Thaller (NASA, Lewis Research Center, Solar and Electrochemistry Div., Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0989*. 9 p. 7 refs. Contract No. E(49-28)-1002.

The redox flow cell energy storage system being developed by NASA for use in remote power systems and distributed storage installations for electric utilities is presented. The system under consideration is an electrochemical storage device which utilizes the oxidation and reduction of two fully soluble redox couples (acidified chloride solutions of chromium and iron) as active electrode materials separated by a highly selective ion exchange membrane. The reactants are contained in large storage tanks and pumped through a stack of redox flow cells where the electrochemical reactions take place at porous carbon felt electrodes. Redox equipment has allowed the incorporation of state of charge readout, stack voltage control and system capacity maintenance (rebalance) devices to regulate cells in a stack jointly. A 200 W, 12 V system with a capacity of about 400 Wh has been constructed, and a 2 kW, 10kWh system is planned. A.L.W.

A79-38192 * # Analysis of a fuel cell on-site integrated energy system for a residential complex. S. N. Simons (NASA, Lewis Research Center, Fuel Cell Projects Office, Cleveland, Ohio) and W. L. Maag (Solar Energy Products Co., Avon Lake, Ohio). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0990*. 10 p. 8 refs.

The energy use and costs of the on-site integrated energy system (OS/IES) which provides electric power from an on-site power plant and recovers heat that would normally be rejected to the environment is compared to a conventional system purchasing electricity from a utility and a phosphoric acid fuel cell powered system. The analysis showed that for a 500-unit apartment complex a fuel OS/IES would be about 10% more energy conservative in terms of total coal consumption than a diesel OS/IES system or a conventional system. The fuel cell OS/IES capital costs could be 30 to 55% greater than the diesel OS/IES capital costs for the same life cycle costs. The life cycle cost of a fuel cell OS/IES would be lower than that for a conventional system as long as the cost of electricity is

greater than \$0.05 to \$0.065/kWh. An analysis of several parametric combinations of fuel cell power plant and state-of-art energy recovery systems and annual fuel requirement calculations for four locations were made. It was shown that OS/IES component choices are a major factor in fuel consumption, with the least efficient system using 25% more fuel than the most efficient. Central air conditioning and heat pumps result in minimum fuel consumption while individual air conditioning units increase it, and in general the fuel cell of highest electrical efficiency has the lowest fuel consumption. A.T.

A79-38193 # Design of a bench model solar receiver for an open-cycle solar/electric system. D. C. Gray (Black and Veatch Consulting Engineers, Kansas City, Mo.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0992*. 7 p. Research sponsored by the Electric Power Research Institute.

The design of a 1 MWt bench model central solar receiver for a solar electric generating plant which employs an open cycle gas turbine as the prime mover is presented. The receiver has a cavity-type geometry and employs silicon carbide tubes as the high temperature heat exchanger surface. The heat exchanger has a U-tube geometry with metal return bends located above the cavity ceiling and outside the radiant zone. Inlet and outlet ducts and headers are located beneath the cavity floor, outside the radiant zone. Joints at the ends of the silicon carbide tubes have been designed to withstand temperatures of up to 1950 F and internal pressures up to 135 psia and to permit a rotation of the centerline axis of the tube. Articulating metal joints with a ball-and-seat geometry have been tested successfully in full-scale tests. Solar testing of the receiver is scheduled for June, 1979. A.L.W.

A79-38194 # Conceptual design of sodium-cooled central receiver solar power plant. B. D. Pomeroy (General Electric Co., Schenectady, N.Y.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0994*. 8 p. Contract No. EM-78-C-03-1725.

A conceptual design and performance and cost estimate for a liquid-sodium-cooled central receiver solar power plant have been completed. In this design, liquid sodium transfers thermal energy from the solar receiver to steam Rankine cycle. The sodium leaves the receiver at a temperature of 593 deg C (1100 deg F) and is conducted to the base of the tower, where it is used to generate superheated steam, or, alternately, may be stored in insulated vessels for use in preventing transients during periods of cloud cover, or to extend the plant operating period. The steam drives a 16.55 MPa/538 deg C/538 deg C (2400 psi/1000 deg F/1000 deg F) reheat turbine which produces a net electrical output of 100 MW. (Author)

A79-38195 # Integrated coal conversion utilization program. W. M. Crim and G. B. Manning (U.S. Department of Energy, Washington, D.C.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0997*. 5 p.

Integrated coal conversion and utilization systems hold the most promise for using coal in an economic and environmentally acceptable manner. A high-temperature open cycle gas turbine/low Btu coal gasification combined cycle plant can be expected to achieve the high efficiency needed to offset the energy losses in cleaning and gasifying coal to compete with oil-fired steam and nuclear baseload systems. Such systems would use materials, internal cooling and components designed specifically for high reliability utility service. This system concept offers potentially lower capital cost, shortened construction time, and higher efficiency than a conventional high-pressure steam power plant. The program visualizes developing a technological base for a cycle embodying a gas turbine with a turbine inlet temperature of 1427 deg C. (Author)

A79-38197 # High energy fuel techniques for combustion driven MHD generators. R. E. Eckels (Gilbert Associates, Inc.,

Reading, Pa.), J. F. Holt (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio), and D. W. Swallow (Maxwell Laboratories, Inc., Woburn, Mass.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1004*. 8 p. 5 refs. USAF-supported research.

Analysis indicates that (35% by mass) aluminum powder added to a toluene base fuel, using an emulsifier as stabilizer, and oxidized with gaseous oxygen, might produce a power density approximately twice the power density of straight toluene fuel. Magnesium powder additive shows a calculated advantage of over 50% in power density. Preliminary results of preparing emulsions which were used to inject such fuels into a 200kwe MHD generator system are described. This program has developed waterless seed-fuel emulsions, as well as several emulsions using water with the surfactant. These preliminary MHD tests were not conclusive in measuring the relative merits of the additive fuel. (Author)

A79-38198 * # Selection and development of small solar thermal power applications. S. A. Bluhm, T. J. Kuehn, and R. M. Gurfild (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1005*. 7 p. 7 refs. Research sponsored by the U.S. Department of Energy.

The paper discusses the approach of the JPL Point Focusing Thermal and Electric Power Applications Project to selecting and developing applications for point-focusing distributed-receiver solar thermal electric power systems. Six application categories are defined. Results of application studies of U.S. utilities are presented. The economic value of solar thermal power systems was found to range from \$900 to \$2100/kWe in small community utilities of the Southwest. (Author)

A79-38199 # A methodology for the comparative ranking of 0.1 to 10 MWe solar thermal electric power systems. J. P. Thornton, K. C. Brown, A. L. Edgecombe, J. G. Finegold, and F. A. Herlevich (Solar Energy Research Institute, Golden, Colo.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1006*. 5 p. 5 refs. Contract No. EG-77-C-01-4042.

A methodology adopted for the comparative analysis and ranking of eight generic types of small solar thermal electric power systems (capacity 0.1 to 10 MWe) in order to determine the most promising options for long-term commercialization is outlined. The collector subsystems are categorized into generic types on the basis of tracking and concentration characteristics. Ground rules of the study are chosen to reflect performance requirements and cost factors in the utility market. A series of modular computer simulation codes is used to identify the cost and performance characteristics of each system, assuming 1990 technology. The ranking procedure incorporates a formalized multiattribute decision analysis technique to establish the preference profile of the decision maker, insuring a high degree of consistency and traceability throughout the analysis. A.L.W.

A79-38200 # Ceramic receivers for solar power conversion. P. O. Jarvinen (MIT, Lexington, Mass.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1008*. 8 p. Research sponsored by the U.S. Department of Energy.

An advanced ceramic dome cavity receiver is discussed which heats pressurized gas to temperatures above 1800 F (1000 C) for use in solar Brayton power systems of the dispersed receiver/dish or central receiver type. Optical, heat transfer, structural and ceramic material design aspects of the receiver are reported and the development and experimental demonstration of a high temperature seal between the pressurized gas and the high temperature silicon carbide dome material is described. (Author)

A79-38201 # Space Laser Power System. W. S. Jones (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). *American*

Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1013. 7 p. 12 refs.

The Space Laser Power System (SLPS) concept developed for NASA requires only a few acres of protected area around the ground receiver in contrast to tens of thousands of acres for the microwave beam of the Solar Power Satellite (SPS) concept, although the SLPS must include features to insure safe operations. For instance, in order to overcome the inability to penetrate heavy clouds (the major inconvenience), multiple ground stations and switching to clear sites is suggested. A description of different parts of the SLPS is presented, with consideration given to the electrical discharge laser (EDL) and the solar-pumped laser (SPL) space options, also noting some systems concepts. It is shown that the overall efficiency from solar energy in space to electrical output on the ground for the microwave SPS is 7.3%, for the EDL system is 6.4%, and for the SPL system is 9.4%. V.T.

A79-38202 * # Solar-pumped lasers for space power transmission. R. Taussig, C. Bruzzone, L. Nelson, D. Quimby (Mathematical Sciences Northwest, Inc., Bellevue, Wash.), and W. Christiansen (Washington, University, Seattle, Wash.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1015. 18 p. 40 refs. Contract No. NAS3-21134.*

Multi-Megawatt CW solar-pumped lasers appear to be technologically feasible for space power transmission in the 1990s time frame. A new concept for a solar-pumped laser is presented which utilizes an intermediate black body cavity to provide a uniform optical pumping environment for the lasant, either CO or CO₂. Reradiation losses are minimized with resulting high efficiency operation. A 1 MW output laser may weigh as little as 8000 kg including solar collector, black body cavity, laser cavity and ducts, pumps, power systems and waste heat radiator. The efficiency of such a system will be on the order of 10 to 20%. Details of the new concept, laser design, comparison to competing solar-powered lasers and applications to a laser solar power satellite (SPS) concept are presented. (Author)

A79-38203 # The Florida Solar Energy Standards Act of 1976. O. G. Hancock, Jr. (Florida Solar Energy Center, Cape Canaveral, Fla.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1018. 4 p.*

The Florida Solar Energy Standards Act of 1976 established the requirements for the Florida Solar Energy Center to write standards for and to evaluate solar energy systems. However, conformance by the industry was optional. The Standards Act of 1976 was amended in 1978 to require conformance as of January 1, 1980. The amended Solar Energy Standards Act of 1976 is presented and its implementation discussed. The Act establishes three primary activities: setting of standards, systems evaluation, and listing of the most reliable designs. The Florida Solar Energy Center has the lead role in implementing this legislation. (Author)

A79-38204 # Solar heated and cooled house in Winter Springs, Florida - A Florida Gas Company Project. O. G. Hancock, Jr. (Florida Solar Energy Center, Cape Canaveral, Fla.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1019. 8 p.*

A79-38205 # Solar heating and load managed/solar cooling of a small commercial building using flat plate collectors. P. R. Sutherland (Florida Power and Light Co., Miami, Fla.) and R. H. Hubbell (Arthur D. Little, Inc., Cambridge, Mass.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1020. 8 p.* Research supported by the Electric Power Research Institute and Florida Power and Light Co.

A solar heating and cooling system has been designed to be retrofit to an existing small office building in Miami. Approximately 1,400 sq. ft. of flat plate collectors will drive two absorption chillers, backed up by an electric reciprocating chiller. The system will use off-peak electricity as well as solar energy to minimize on-peak electrical loads. Various modes of operation will be tested to optimize compatibility with the electric utility and maximize energy savings. (Author)

A79-38206 # Solar heating and cooling of the Georgia Power Company Office Building in Atlanta. W. R. Hensley (Georgia Power Co., Atlanta, Ga.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1024. 4 p.*

A79-38207 # Solar total energy - Large scale experiment. E. J. Ney. *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1025. 3 p.*

The first industrial application of the Solar Total Energy Program (STEP) consisting of the design, construction, operation and technical evaluation of a system which will supply electrical power and process heat with heating, cooling and domestic hot water supplies to an industrial plant at Shenandoah, Ga. is described. The system is sized to supply 3.5 MW thermal power and 300 kW electrical power. It will supply 169C process steam and the major portion of the plant electrical heating, air conditioning and hot water requirements. The 25,000 sq ft plant will employ 90 people, later expanding to 42,000 sq ft and 300 employees. The system circulates heat transfer fluid through tubes of a solar collector field which is heated to 316C and then pumped to a heat exchanger or thermal storage for later use. Generation of electricity, process steam and of the working fluid for heating, air conditioning and hot water are described. It is scheduled to become operational in 1981. A.T.

A79-38208 # Opportunities for solar thermal energy in Puerto Rico. A. Cobas. *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1028. 5 p.*

A79-38209 # The Joint Saudi Arabian-United States Solar Energy Program. M. Z. Lowenstein and I. C. Smith (Solar Energy Research Institute, Golden, Colo.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1029. 6 p.*

In October, 1977, Saudi Arabia and the United States signed a project agreement for cooperation in the field of solar energy (SOLERAS). The Solar Energy Research Institute (SERI) has been designated as the Operating Agent for the SOLERAS Program. This paper discusses the objectives and scope of the program and the benefits anticipated by both countries. Program organization is outlined and funding for each program area is detailed. (Author)

A79-38316 Characterization and formation of submicron particles in coal-fired plants. R. D. Smith, J. A. Campbell, and K. K. Nielson (Battelle Pacific Northwest Laboratories, Richland, Wash.). *Atmospheric Environment*, vol. 13, no. 5, 1979, p. 607-617. 24 refs.

A79-38374 Solar power satellites - Microwaves deliver the power. W. C. Brown (Raytheon Co., Microwave and Power Tube Div., Waltham, Mass.). *IEEE Spectrum*, vol. 16, June 1979, p. 36-42.

While microwave power transmission from the Solar Power Satellite (SPS) network provides such advantages as availability of the sun's energy for more than 99% of the year, supply of five GW of power from each SPS and dc-to-dc transmission efficiency of more than 60%, there are three possible environmental problems associated with the SPS system: radio frequency interference (RFI), local heating of the ionosphere, and possibly harmful biological effects.

The RFI and ionospheric problems are being studied by DOE and safety features, such as a pilot beam for the transmitting antenna to track are planned, to keep microwave beams from wandering off target and affecting people. The microwave transmission system envisioned in the DOE/NASA reference design comprises three parts: 1) The conversion of dc power to microwave power. 2) The formation and control of microwave beams and 3) The collection of the microwave energy and its conversion into dc energy. The design uses the linear-beam tube in its klystron format; however, the crossed-field device in either magnetron-directional-amplifier or amplatron is still an option for the final design. V.T.

A79-38375 * NASA takes stock. R. A. Frosch (NASA, Washington, D.C.). *IEEE Spectrum*, vol. 16, June 1979, p. 44-49.

The history of NASA activities and achievements in the past decade is reviewed with consideration given to the Apollo expeditions and the post-Apollo planetary exploration. Progress in spaceborne astronomy and in satellite communications is characterized as revolutionary. It is also noted that Landsat alone may eventually repay the United States for the cost of the entire space program. Special attention is given to the Shuttle program which will be the key to all operations in space for the next decade including the Galileo mission to Jupiter (1982) and the Space Telescope (1983). Future missions could include a Venus orbiter with imaging radar to finally penetrate the cloud cover of the planet and to map its surface; a rover or sample return expedition to Mars; a Saturn orbiter combined with a probe of its Titan satellite, and an examination of Halley's Comet. Finally the next decade should bring the data needed to make a 'go' or 'no go' decision on the concept of SPS that would beam solar energy into earth stations. V.T.

A79-38376 # Converting coal to liquid/gaseous fuels. J. T. Stewart and M. G. Klett (Gilbert Associates, Inc., Reading, Pa.). *Mechanical Engineering*, vol. 101, June 1979, p. 34-41. 16 refs.

A summary of the status, process development, product characteristics and costs of commercially viable coal gasification and liquefaction is discussed. Characteristics of fixed, entrained and fluidized bed gasification processes and data on existing and planned U.S. plants are presented, including gas combustion properties and economics. The three basic methods for coal liquefaction, hydrogenation, pyrolysis and the indirect route through gasification are discussed, noting that no commercial plants are operating in the U.S. today, but several advanced processes are being developed. Coal-derived liquid fuels are characterized and estimated economics of commercial plants tabulated. It is concluded that the economics of synthetic natural gas and coal liquids are not favorable as long as the supply of petroleum based oil and gas is adequate, so that government support will be needed to encourage synfuel production and resolve environmental issues, with low production of synfuels expected until oil production levels out in the 1980's. A.T.

A79-38387 The effect of hydrogen addition on ignition delays and flame propagation in spark ignition engines. M. J. Rauckis and W. J. McLean (Cornell University, Ithaca, N.Y.). *Combustion Science and Technology*, vol. 19, no. 5-6, 1979, p. 207-216. 21 refs.

The results of an experimental investigation of the effect of supplemental hydrogen (up to 30 percent of the total fuel energy) on the combustion process in a CFR engine are reported. The hydrogen was added under otherwise constant conditions so that chemical properties were varied under constant hydrodynamic conditions. Calibrated cylinder pressure traces, averaged over many cycles, were incorporated into a two-zone thermodynamic analysis to determine the mass fraction burned as a function of crankangle. The techniques employed enabled changes in the induction period and combustion duration of the order of 0.1 ms to be resolved. The added hydrogen resulted in significant reductions in ignition delay or induction times, especially in lean mixtures. Reductions were greater with increased

fractions of hydrogen. Once a turbulent flame was well established, the hydrogen had a relatively small effect on the burning rate. The results are consistent with a description of the combustion process which includes an induction period dominated by chemical dynamic effects and a turbulent burning period dominated by turbulent transport effects. Added hydrogen also led to improved efficiency and less cycle-to-cycle pressure variations. (Author)

A79-38434 Enhancement of magnetic separability in coal liquefaction residual solids. I. S. Jacobs and L. M. Levinson (General Electric Co., Schenectady, N.Y.). (*American Institute of Physics and Institute of Electrical and Electronics Engineers, Annual Conference on Magnetism and Magnetic Materials, 24th, Cleveland, Ohio, Nov. 14-18, 1978.*) *Journal of Applied Physics*, vol. 50, Mar. 1979, pt. 2, p. 2422-2424. 20 refs. Research supported by the Electric Power Research Institute.

The conversion of coal to a clean fuel through liquefaction requires the physical separation of undissolved sulfur-rich mineral matter. The hydrogenation-liquefaction reaction produces residual solids in which the original coal impurity pyrite, FeS₂, has largely been converted to pyrrhotite, Fe(1-x)S, which is a complex nonstoichiometric sulfide. By using thermomagnetic analysis and Mössbauer spectroscopy it is shown that the iron sulfide in coal liquefaction residues corresponds to an intermediate pyrrhotite. Striking transformations between various magnetic and nonmagnetic states are induced by thermal treatments in inert or sulfidation atmospheres. The kinetics of the transformations are strongly influenced by prior thermal and atmosphere history. Transformation to a high magnetization state has practical application wherein magnetic separation techniques become attractive for the liquid solids separation step in coal liquefaction. (Author)

A79-38481 Heavy duty diesel particulate emission factors. T. M. Baines, J. H. Somers, and C. A. Harvey (U.S. Environmental Protection Agency, Office of Air and Water Programs, Ann Arbor, Mich.). *Air Pollution Control Association, Journal*, vol. 29, June 1979, p. 616-621. 18 refs.

Particulate emissions from various heavy-duty diesel engines have been collected by diverting a fraction of the exhaust into a dilution channel and filtering it to determine the particulate mass and organic content. The sampling system, experimental procedures, and the method of computing particulate emission factors from truck and bus fuel consumption and average speed data from New York and Los Angeles are discussed. The average particulate steady state emission test results for 2-stroke engines were 4.74 g/kg fuel and for 4-stroke engines 2.64 g/kg fuel. A particulate emission factor range of 0.8 to 1.3 g/kg fuel was computed from average particulate emission results. The emission factor range for urban areas which permit only local buses is 1.8 to 2.7 g/kg of particulate, and diesels emit a nationwide total of 88,000 metric tons of particulate/year. A.T.

A79-38500 Accounting for intangibles in a present worth comparison of advanced power generation alternatives. B. D. Pomeroy and J. J. Fleck (GE Corporate Research and Development Center, Schenectady, N.Y.). (*IEEE, ASME, and ASCE, Joint Power Generation Conference, Dallas, Tex., Sept. 10-13, 1978.*) *IEEE Transactions on Power Apparatus and Systems*, vol. PAS-98, May-June 1979, p. 1122-1129. Research sponsored by the Electric Power Research Institute.

A cost-benefit method for assessing advantages to be derived from developing different advanced electric power generation cycles is presented. A modified present worth analysis of revenue requirements is carried out to account for inflated capital, fuel and labor costs, and generation expansion techniques are used to estimate market penetration. The impact of 26 intangibles, including development risk, plant safety, waste handling and disposal, flexibility of

siting and environmental effects, is assessed by probabilistic arguments. The method is applied to three potential advanced power generation cycles: steam (3500 P/1000 F), atmospheric fluidized bed, coal; gas turbine (water cooled) combined, low BTU gasifier, coal; open cycle MHD, coal. The most significant intangible was found to be R & D time; R & D costs were low in comparison with potential savings. The present tax structure was found to reduce savings by penalizing cycle alternatives which are fuel-efficient but capital-intensive. C.K.D.

A79-38529 Transient analysis of the rectified superconducting alternator. T. A. Stuart (Toledo, University, Toledo, Ohio). *IEEE Transactions on Aerospace and Electronic Systems*, vol. AES-15, May 1979, p. 356-365. 9 refs. Grants No. AF-AFOSR-76-2997; No. AF-AFOSR-77-3413.

A set of five differential equations is derived to describe the transient electrical behavior of a three-phase superconducting alternator connected to a full-wave thyristor bridge. The approximation of constant flux linkages for the rotor circuits is utilized to reduce the number of numerical integrations from five to two. This produces a very efficient algorithm that is quite useful for studies requiring a large number of simulations. Numerical results based on the parameters of a 10-MVA superconducting machine are included.

(Author)

A79-38565 # Evaluation of a sodium heat pipe/thermal energy storage unit utilizing LiF-MgF₂-KF phase change material. D. Feuermann and D. L. Jacobson (Arizona State University, Tempe, Ariz.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, Paper 79-1095*. 8 p. 6 refs. USAF-sponsored research.

A specific example is used to analyze the performance of energy storage in the form of latent heat of fusion. Experimental data for transient heat transfer in presence of change of phase are presented. The resistance to heat transfer during the quasi-steady state of change of phase, neglecting heat capacities of liquid and solid material, is found to be an indicator of accessibility of the stored energy and depending on the application is recognized as an important design variable. The nonideal behavior of the salt makes analytical analysis difficult and experimental evaluation of the performance variables is necessary.

(Author)

A79-38566 # Performance analysis of phase change thermal energy storage/heat pipe systems. S. Peck and D. Jacobson (Arizona State University, Tempe, Ariz.). *American Institute of Aeronautics and Astronautics, Thermophysics Conference, 14th, Orlando, Fla., June 4-6, 1979, Paper 79-1096*. 7 p. 6 refs. USAF-sponsored research.

Several candidate geometries for thermal energy storage units utilizing a eutectic phase change material are investigated to determine the effect geometry has on the performance of such units. The solidification heat transfer problem is solved for each geometry to determine the resistance to heat transfer as a function of the fraction of solid material in the unit. Results are correlated by using a significant dimension, storage unit volume/heat transfer area squared. The performance of storage units is discussed in terms of temperature drop, power output, the time power is available, and volume. Results of an analysis of an arbitrary cost function are given, which show that the plane wall geometry generally has superior performance.

(Author)

A79-38572 Solar chemical reactors (Les réacteurs chimiques solaires). J. Villiermaux (Nancy, Ecole Nationale Supérieure des Industries Chimiques, Nancy, France). *Entropie*, vol. 15, Jan.-Feb. 1979, p. 25-31. 11 refs. In French.

Problems encountered in the design of solar chemical reactors are examined. The different types of chemical reactions which may be envisioned for solar chemical reactors are considered. Difficulties

arising in theoretical analyses of solar chemical reactors as the result of the necessary inclusion of the photon energy balance, which is irreducibly coupled to mass, heat and impulsion balances, are discussed. Special attention is given to the importance of heat and mass transfer phenomena at the high temperatures that would be present in solar chemical reactors. The state-of-the-art of solar chemical reactor design is discussed. Schematic diagrams of gas-solid reactors are presented. Research programs underway in France and the United States is described, and areas in which further research efforts are needed are identified. C.K.D.

A79-38573 Solar and chemical energy (Energétique chimique et énergie solaire). J. Mahenc (Toulouse III, Université, Toulouse, France). *Entropie*, vol. 15, Jan.-Feb. 1979, p. 32-42. 9 refs. In French.

It is conceivable that solar energy could be used in endothermic physicochemical processes, either for the purpose of separation or for chemical reactions. Chemistry can solve problems of converting, storing and transporting solar energy. The use of solar energy in thermal form raises the problem of the temperature at which it is collected. The sun is comparable to a black body radiating at 6000 K, and if degradation of its energy is to be avoided it should be collected at as high a temperature as possible. This can be demonstrated by making a thermodynamic analysis of an endothermic process which in fact only requires a low-temperature heat delivery (less than 200 C). The simplicity of the collecting devices is not generally compatible with the best energy use of the solar flux. Similarly, chemical heat conveyors degrade energy. In the field of conversion and storage, thermogalvanic motors offer solutions that are of interest from the energy point of view: a thermodynamic analysis of their operation makes it possible to eliminate certain inefficient systems.

(Author)

A79-38574 The THEK program for solar energy plants with 'distributed' converters (Programme THEK de centrales solaires à collecteurs distribués). G. Peri (Aix-Marseille I, Université, Marseille, France). *Entropie*, vol. 15, Jan.-Feb. 1979, p. 43-47. In French.

The THEK development program for solar energy plants in the medium-power (100 kW) range is discussed. 'Distributed' heliothermal converters in modular units will be used to convert solar energy to heat, most of which will be used at a cascade of decreasing temperatures to meet as many energy needs as possible. Some thermal energy will be converted to electricity to satisfy needs which specifically require this form of energy. Capture and concentration of solar energy will be assured by flat triangular mirrors in an arrangement approximating a paraboloid of rotation. The concentrated energy will be extracted by a neat transport fluid (Giloterm TH or Mobiltherm 605) capable of carrying heat up to 340 C at atmospheric pressure. The converter will have an altazimuthal mount to allow solar tracking. The first step of THEK, the development of the converter, is nearing completion, and definition of an industrial prototype has been undertaken.

C.K.D.

A79-38575 Heat storage and transient regimes in solar electric plants (Stockage thermique et régimes transitoires dans les centrales électrosolaires). J.-L. Peube, B. D'Utruy, and D. Blay (CNRS, Laboratoire d'Energétique Solaire, Poitiers, France). *Entropie*, vol. 15, Jan.-Feb. 1979, p. 48-54. 6 refs. In French.

The CNRS solar power station at Odeillo is described. The 1000 kW solar furnace comprises 63 45 sq m heliostats; reflected radiation is concentrated by a parabolic mirror 54 m long and 40 m high. The primary heat loop is composed of the solar receptor and heat reservoir; the secondary loop is composed of heat exchangers, the turbo-alternator, the condenser, and the aerorefrigerant. The heat transport fluid is hydrogenated terphenyl. The effect of the aleatory nature of the solar flux on the heat balance of plant components is examined, and heat losses in the network and heat reservoir are

analyzed. It is shown that the quality of heat restitution is primarily dependent on good stratification of heat in the reservoir on losses in the circuits in transient regime. Conditions for heat storage and regulation of solar electric plants which assure the accumulation and restitution of heat at constant temperature independent of variations in solar flux are identified. C.K.D.

A79-38576 International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volumes 1, 2 & 3 (Internationales Sonnenforum, 2nd, Hamburg, West Germany, July 12-14, 1978, Tagungsberichte. Volumes 1, 2, & 3). Forum sponsored by the Deutsche Gesellschaft für Sonnenenergie und Coopération Méditerranéenne de l'Energie Solaire. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978. Vol. 1, 653 p.; vol. 2, 556 p.; vol. 3, 618 p. In German, English, and French. Price of three volumes, \$70.

Papers are presented on all aspects of the solar energy conversion problem, including solar architecture, high-temperature collectors, solar power stations, house heating and cooling, selective materials, photovoltaic conversion, air conditioning, flat plate collectors, bioconversion, measurement and simulation of solar radiation, wind energy, heat transport, and economic and legal aspects. Individual topics presented include the development of interactive computer programs for computing the energy demands between sloping surfaces and the environment, thin-film solar absorber consisting of Au particles in SiO₂, active heat insulation through a solar low temperature heating system integrated in the walls of a house, design of vertical axis wind turbine, and solar energy systems and life cycle cost. P.T.H.

A79-38577 A 'real life' solar air conditioned house project. S. V. Szokolay (Queensland, University, Brisbane, Australia). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 1-16.

After a brief discussion of the relevance and context of the Mount Cotton Solar House project, the design is described under three headings: (1) house design, (2) system design, (3) control system. The introduction of a cold-side buffer storage is discussed in some detail. The concluding economic analysis shows that in Brisbane the pay-back period would be over 75 years, but in remote tropical areas of Australia this would be less than 10 years. (Author)

A79-38578 Which is the true solar house (Qu'est la véritable maison solaire). M. Touchais. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 17-28. In French.

The true solar house is by definition a dwelling that absorbs directly all the radiation reaching its exterior surface, to which can be added also part of the radiation in the immediate neighborhood. A general mathematical model of a solar house is proposed. The concept of an ecological house is presented, which is a house that uses the luminous and atmospheric environment for the comfort of its inhabitants. P.T.H.

A79-38579 Design of the Eichenau solar house (Planung Solarhaus Eichenau). W. Wendler. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 29-40. 5 refs. In German.

Some very general principles of energy-saving house design are briefly discussed, with attention given to heat insulation and solar collection and conversion. In the cold season the south-facing wall absorbs heat while in summer it is shaded from the sun. The collectors are integrated on the south roof surface. The south and north roof surfaces, under which air passes, and the solar-irradiated side surfaces, behind which air passes, serve as low-efficiency collector. The warm air is ventilated to the living rooms. P.T.H.

A79-38580 Traditional architecture in West Africa and passive methods of cooling in the Tropics. K. Talib (Lagos, University, Lagos, Nigeria). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 43-51. 8 refs.

An analysis of methodology and techniques of houses in W. Africa forms the first part of this paper. The second part deals with possibilities of including these techniques in passive cooling of modern buildings. Several attempts in Nigeria and in two houses (one in hot-humid and the other in hot-dry for private clients) designed by the author are analyzed. One of the houses uses thick mud walls and thermal pond and relies on cooling by night exposure in hot-humid. The other house uses wind-tower, thermal ponds and semi-underground spaces for varying activity cycle in hot-dry region of northern Nigeria. (Author)

A79-38581 Solar energy pattern on building vertical walls of different orientations. I. A. Sakr and N. H. Helwa (National Research Centre, Solar Energy Laboratory, Cairo, Egypt). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 59-72.

The meteorological considerations which should be taken into account in the design of solar houses are briefly reviewed, and conditions in Egypt are discussed in particular. It is shown that the mean transmissivity is higher in Aswan than in Giza. Expressions for the global radiation on a vertical surface are derived. Calculated values for the total radiation at a vertical surface for different orientation for the middle of each month at 9, 12, and 15 o'clock for 1976 at Giza and Aswan are plotted. Some relations taking into account the effect of wall absorption on the thermal capacity of the building are given. P.T.H.

A79-38582 Active and passive solar energy utilization in urban construction (Aktive und Passive Sonnenenergienutzung im Städtebau). W. Breustedt (Battelle-Institut, Frankfurt am Main, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 73-82. 5 refs. In German.

The boundary conditions for solar energy utilization in urban planning are established. A concrete planning example is considered, in which it is shown how the radiation conditions are obtained for construction planning and how the requirement for shade-free surfaces can be integrated in the city planning. P.T.H.

A79-38583 Development of low-temperature solar collectors and collectors for thermal and photovoltaic conversion (Die Entwicklung von Solarkollektoren für Nieder-temperaturniveau und von Kollektoren für Thermische und photovoltaische Umwandlung). H. Kleinwächter, J. Kleinwächter, and K.-H. Dröge (Forschungs- und Entwicklungslabor, Lörrach, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 83-106. In German.

Because of the relatively low energy density of solar radiation of 1 kW/sq m, concentrators are needed for producing process heat and driving steam for thermal power plants of high Carnot efficiency and for better utilization of expensive photovoltaic converters. Design problems for low-, medium-, and high-power concentrators are discussed. Means of increasing the radiation density by optical projection or superposition of several ray bundles are examined. P.T.H.

A79-38584 Critical study of energy parameters of solar energy /illumination and concentration/ - Application to catoptric collectors (Etude critique des grandeurs énergétiques de l'énergie

solaire /éclairage et concentration/ - Application aux capteurs catoptriques). L. Aiache and J. P. David (Aix-Marseille III, Université, Marseille, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 107-119. 13 refs. In French.

In this paper, the authors give a critical survey of energetical quantities with mathematically rigorous basis and local definitions of irradiation and concentration. They then apply these concepts to various solar mirror systems, compare the results obtained by this method with previous results, and emphasize the double aim of catoptrical collectors. (Author)

A79-38585 Study of a thermal converter using both the concentration and the greenhouse effects. J. Brodin, M. Laug, V. V. Pham, and C. Sinnasse (Ecole Nationale Supérieure de l'Aéronautique et de l'Espace; Toulouse, Centre d'Etudes et de Recherches, Toulouse, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 121-139. 6 refs.

A thermal converter is realized with a parabolocylindrical concentrator and a boiler. The latter, placed at the focus of a concentrator, is a parallelepiped glass-covered box which encloses three automobile radiators connected in series. One of the glass surfaces is facing the sun and the other facing the concentrator. The boiler is thus illuminated by the direct flux and the reflected concentrated flux. An analytical and experimental study on the concentration with a static regime is done. (Author)

A79-38586 The development of a stationary concentrator. J. C. McVeigh (Brighton Polytechnic, Brighton, England). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 141-147. 6 refs. Research supported by Fortress Engineering.

A stationary collector with a compound parabolic concentrator has been developed for countries with a relatively high proportion of diffuse radiation. These collectors have several advantages over the traditional flat plate collector; for example the area of the absorber surface relative to the collector panel area is small. This enhances the performance under moderate radiation conditions and leads to economies in production. (Author)

A79-38587 Suntrack-systems for solar concentrators. A. de Gezelle (Leuven, Katholieke Universiteit, Louvain, Belgium). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 151-161.

The basic design concept of several systems for tracking the sun in solar concentrator applications are presented. First the block diagram of a general system is proposed, showing the relationships between sensors, A/D converters, comparators, switches, motor, scanners, and clock. The particular sensor schemes considered include angular sensors, which are placed side by side at an angle less than 180 deg; a camera obscura arrangement; a cell array for one-dimensional and a matrix for two-dimensional tracking; a shadow sensor, a real-time system based on the use of microprocessor to calculate the exact position of the sun, and a hybrid method based on principles of the first mentioned systems. Tests have proved the angular sensor to be simplest, while the camera obscura and array sensor are more accurate but require careful design. P.T.H.

A79-38588 Influence of emissivity and pipe size on thermal losses of linear collectors measured under different vacuum conditions. C. Bellecci, M. Conti, A. Visentin, and R. Visentin (Calabria, Università, Cosenza, Italy). In: International Solar Forum 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 163-174.

The thermal losses of linear collectors in a cylindrical geometry were measured at different pressures down to 0.00002 mm Hg on

samples with thermal infrared emissivity ranging from 0.1 to 1 and in the temperature range 100-500 C. At atmospheric pressure the convective losses are almost independent of gap size between the pyrex pipes in the gap range 2-1.25 cm. An abrupt reduction occurs when the gap width is near 1 cm. The IR emissivity of the pipes was then varied by coating them with IR reflective metal oxide. Curves are presented from which one can evaluate the reduction of thermal losses due to emissivity and/or vacuum. P.T.H.

A79-38589 Photoelectric conversion in monomolecular layer formations (Photoelektrische konversion in monomolekularen Schichtverbänden). H. Kuhn (Max-Planck-Institut für Biophysikalische Chemie, Göttingen, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 175-182. In German.

The process of light-induced oriented charge separation in plant photosynthesis is discussed in reference to energy solar energy conversion. It is suggested that artificial systems for light-induced oriented charge separation can be obtained at interfaces by assembling different kinds of interlocking molecules to form organized layer formations. P.T.H.

A79-38590 The concept of the 1 MW/el/ solar thermal power plant of the European economic community. J. Hofmann (Messerschmitt-Bölkow-Blohm GmbH, Munich, West Germany) and J. Gretz (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro Comune di Ricerche, Ispra, Italy). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 185-193.

The 1 MWe solar thermal demonstration power plant of the central receiver type, being implemented by the EEC is surveyed. The project, in its design stage, is supported by the governments of West Germany, France, and Italy and is located in Sicily. Attention is given to the major subsystems consisting of: (1) heliostat field, (2) receiver and tower, (3) electrical power conversion system, (4) thermal storage. Two main aspects are stressed: (a) the plant is to supply electric power into the public grid as opposed to being purely developmental, (b) the receiver, of the cavity type, utilized water/steam as the working medium, allowing the use of conventional power generation equipment. Two types of heliostats are to be used. One will measure the reflected beam to make adjustments, while the other will use a computer to calculate proper orientation from the time of day. Thermal storage will be accomplished by two storage tanks containing molten salt. The plant is expected to be ready for experimental testing at the end of 1980. M.E.P.

A79-38591 Design problems of the hydraulic network in a linear collector power plant. O. Barra, E. P. Caratelli, M. Conti, M. El Sawi, and R. Visentin (Calabria, Università, Cosenza, Italy). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 195-207. 5 refs.

A number of design parameters of a primary thermohydraulic circuit of a solar power plant are examined. With the aid of a mathematical model the influence of these parameters on the pumping power and the collected thermal power is demonstrated. The problem of the circuit sensitivity to the values of some of the design parameters is also treated. (Author)

A79-38592 Solar central receiver power plants with sodium heat transfer - Design, Exergy flow and economics. F. K. Boese, W. Jansing, S. Kostzewa, and D. Stahl (Internationale Atomreaktorbau GmbH, Bergisch Gladbach, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 209-232. 10 refs.

The design of a tower type solar power station, using sodium as the heat transfer fluid, is studied. The sodium is heated from 548 K

to 798 K in the receiver, then stored and used later to generate steam. After a 24 hour hold 4.0 MWh can be generated. The heliostat and tower layout are discussed with heat flux density averaged over the active surface given as approximately 21 W/sq cm. The plant's steam generator, sodium pumps, and steam turbine are also covered. Attention is given to the exergy flow and the reduction of exergy loss, which is the greatest in the heliostat field and the receiver. Economic prospects are also stressed noting that solar power electricity costs can be compared to conventionally generated electricity costs as a function of cost escalation. With an oil price escalation rate of over 6% per year, solar central receiver power plants are expected to be feasible in the early 21st century. M.E.P.

A79-38593 Experimental researches concerning the use of solar energy in the generation of electric energy. S. Petrescu, A. Danescu, N. Baran, and S. Dimitriu (Bucuresti, Institutul Politehnic, Bucharest, Rumania). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 233-245. 5 refs.

The paper presents theoretical and experimental aspects concerning the cylindrical parabolic type solar radiation receivers; the paper comprises the concentrated radiation receivers by whose aid superheated steam has been obtained. The steam jet is actuating the pilot turbine, coupled to a small electric generator. (Author)

A79-38594 A contribution to solution of the energy crisis - Proposed solution: Aerothermal plants (Contribution pour résoudre la crise de l'énergie - Solution proposée: Les centrales aérothermiques). E. Nazare. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 247, 250-264. In French.

It is suggested that solar energy could be used to produce electricity in aerothermal plants, in which solar-heated air provokes the formation of artificial cyclones in vortex towers 300 to 600 m high. The kinetic energy of the rotating air would then be captured by appropriate air-driven turbines. It is argued that this method of energy production would be pollution-free and potentially cheaper than nuclear energy. C.K.D.

A79-38595 System analysis of solar space heating (Systemanalyse solare Raumheizung). H. Birnbreier (Brown, Boveri and Cie. AG, Heidelberg, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 267-278. In German.

The influence of a solar heating system main components on the heat gain from solar radiation is studied. Consideration is given to the solar collectors, the heat transfer medium, system losses, the heat exchanger, storage tank capacity, and collector area. Equations for calculating the needed component dimensions, their performance, and operating costs are given stressing that good results can be achieved only if the components are properly matched. It is concluded that: (1) collector type and surface area determine the layout of the other components, (2) there is no perfect component dimension that will always ensure maximum efficiency, and (3) accurate predictions of useful solar energy gain require extensive computer simulation in addition to knowledge of the climatic data. M.E.P.

A79-38596 Active heat insulation through solar low-temperature system that can be integrated into the house wall (Aktive Wärmedämmung durch ein in die Hauswand integrierbares, solares Niedertemperaturheizsystem). W. Körner (Kassel, Gesamthochschule, Kassel, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 281-294. 9 refs. In German.

A compact heating system is developed by integration of collector and night storage heating in the walls of a house, which in comparison to passive heat insulation transfers the energy striking

the outer wall to the inner wall. Under optimum conditions an average inner wall temperature of 25°C in winter is expected. The energy requirements of fully insulated dwelling units could be reduced to 40%. The results of the technical-economical optimization and initial experiments are presented. (Author)

A79-38597 Experimental project on the utilization of solar energy in domestic hot water heating in Iraq. T. M. Rabjah (National Centre for Engineering and Architectural Consultancy, Baghdad, Iraq). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 309-318.

Details of a solar water heating system for a one story commercial building in Baquba, Iraq are presented. The system, which will capitalize on Iraq's prolonged sunshine, is intended to provide hot water for the kitchen and workers' showers. Specifications of the flat-plate water type collectors which are utilized due to their construction simplicity, are given. The steel piping, 4000 liter storage tank, 1.1 liter/sec capacity 220 v pumps and electric auxiliary heater are also discussed. System operation, which includes operation of the auxiliary heater when the tank's output temperature is less than 95°F, is covered. Data will be collected when the system is in operation considering the possibility that the project will lead to a more comprehensive program of solar energy utilization in Iraq. M.E.P.

A79-38598 Solar energy utilization in comparison with utilization of other energy types (Solar-Energienutzung im Vergleich mit der Nutzung anderer Energiearten). H. Krimminger (München, Fachhochschule, Munich, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 321-331. In German.

The annual costs of an installation using solar energy as source are compared with those of the same type of installation using different energy sources, and it is shown that on the basis of 1978 prices, the nonsolar installation costs were less than those for the solar installation. But since energy costs are increasing more rapidly than capital costs, smaller installations consuming less energy have good future prospects. Solar energy installations will become very popular in the near future. P.T.H.

A79-38599 Thin film solar absorber consisting of Au-particles in SiO₂. W. Brünger (Tübingen, Universität, Tübingen, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 351-357. 6 refs.

A selective absorptance coating for solar energy systems has been created by an Au-SiO₂ thin film coating process. The procedure involves simultaneous evaporation of gold from a tungsten boat and deposition of SiO₂ by electron beam evaporation. Reflectance measurements performed during the evaporation process permitted determination of the point at which minimum reflectance is attained. The coating shows an absorptance to solar radiation of 88 + or - 1% and a hemispherical emittance of 0.014 + or - 0.005. The absorptance to emittance ratio is thus 63. J.M.B.

A79-38600 Temperature dependence of selective properties for black chromium solar absorbers. J. Vuletin, M. Bosanac (Split, Sveuciliste, Split, Yugoslavia), F. Marcelja (Split, Sveuciliste, Split, Yugoslavia; Selenia-Industrie Electroniche Associate S.p.A., Rome, Italy), and P. Kulisic (Zagreb, Sveuciliste, Zagreb, Yugoslavia). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 359-365. 7 refs.

Temperature dependence of solar absorptance and infrared emittance for black chromium samples have been investigated. It was found that selective properties of the samples were improved if they were heated in air up to temperature of about 600 K. Once heated the samples will maintain the selectivity after cooling to room temperature. (Author)

A79-38601 **Cu₂S-CdS thin-film solar cells (Cu₂S-CdS Dünnschicht-Solarzellen).** F. Pfisterer and W. H. Bloss (Stuttgart, Universität, Stuttgart, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 369-384. 21 refs. In German.

A technology for the production of large-area Cu₂S-CdS thin-film solar cells based on CdS-evaporation and the dipping process to form the Cu₂S-layer has been developed with special emphasis on inexpensive materials and fabrication steps. By comparison of various technologies it is found that the topotaxial exchange reaction to form the Cu₂S-layer seems to be superior to other processes. The technology described here results in cells with efficiencies of 5.5% and with high stability. (Author)

A79-38603 **Encapsulation of terrestrial solar cell arrays by hydrocarbon foils transparent for both visible and infrared radiation.** P. Brennecke, H. H. Ewe, and E. W. Justi (Braunschweig, Technische Universität, Braunschweig, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 397-408. In German.

For the purpose of encapsulating solar cells to protect them from the environment, the use of the same materials used for photothermal collector coatings is not recommended, since the current production of solar cells decreases greatly as the temperature increases. The search for a suitable coating instead should focus on materials that are transparent in both the visible and infrared. Theoretical considerations show that this is only possible in materials that avoid polar bonds through their dipole vibrations and rotations. Recommended are organic foils without halogen, metal, and silicon ions and with as pure as possible homopolar bonds, such as special polymerizates of polypropylene. These foils meet all requirements and limit heat concentration to 2.5 C at 600 W/sq m insolation. P.T.H.

A79-38604 **Analysis of a 1 kW photovoltaic generator with concentration.** D. Esteve, D. Folle, and G. Vialaret (CNRS, Laboratoire d'Automatique et d'Analyse des Systèmes, Toulouse, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 411-420.

The purpose of this communication is to present a photovoltaic generator which is working in Toulouse, France. A detailed description of the whole system is given, including the first experimental test results. From the beginning of the studies two years ago, we have collected many economical data, so that we can now present a realistic estimation for the photovoltaic peak-watt price, from which conclusions are drawn and the most likely development in the photovoltaic conversion area is made precise. (Author)

A79-38605 **Solar system - Solar generator-inverter-asynchronous motor-pump (Solarsystem - Solargenerator-Wechselrichter-Asynchronmotor-Pumpe).** R. Hanitsch (Berlin, Technische Universität, Berlin, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 423-434. In German. Research supported by the Technische Universität Berlin.

The author presents a solar system which is designed to take care of waste water. The coupling unit between the solar generator and the drivemotor for the submerged pump is an alternator developed particularly for this purpose. (Author)

A79-38606 **Operating systems for solar electric energy supplies (Betriebssysteme für solarelektrische Energieversorgungen).** H. K. Köthe (Varta Batterie AG, Kelkheim, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 435-449. In German.

The operating system of a solar energy generator must ensure that the battery is sufficiently and properly loaded and protected against unnecessary discharges and extreme low discharges. The main types of operating systems are characterized, with attention given to systems with blocking diode, transistor, shunt regulators, and 2-point regulators. The line of SOLARZET devices for different environmental and service conditions is briefly described, including a splash proof design with power gradation up to 30, 60, or 90 W, a design for interior use with same power gradation, and a design for large installation or scientific purposes with power gradation up to 300, 600, 900, or 1200 W. P.T.H.

A79-38607 **Performance of an intermittent ammonia-water solar refrigerator operating with a flat plate collector.** A. Venkatesh and M. C. Gupta (Indian Institute of Technology, Madras, India). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 453-472. 5 refs.

The paper presents the results of the theoretical analysis of an intermittent ammonia-water solar refrigerator obtained by simulating the processes of the cycle in an IBM 370 computer. Also presented in the paper are the experimental results of such a solar refrigerator of 1 sq m exposed area and a comparison of the theoretical and experimental results in the initial solution concentration range of 0.5 to 0.65. (Author)

A79-38608 **Solar air conditioning and refrigeration in arid regions (Conditionnement et réfrigération solaire en zone aride).** P. Matarasso (CNRS, Paris, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 473-483. In French.

Every solar refrigeration process suitable for arid land must work with an air cooled condenser and absorber. It is shown that such equipment can be made by adapting commercially available absorption machines to concentrators presently developed. Solar absorption cooling is compared to solar cooling with Rankine cycle at different level of cooling and different scales. Preliminary economic considerations are given. (Author)

A79-38609 **System selection and optimization of a solar thermal installation for cooling, heating, and warm water heating (Systemauswahl und -Optimierung einer solarthermischen Anlage zur Kühlung, Heizung und Warmwassererzeugung).** F. D. Heidt and B. Lang (Dornier System GmbH, Friedrichshafen, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 487-501. In German.

The design studies for a solar energy system for a large solar guest house were carried out on the basis of morphological evaluations and system optimization methods. The building consists

of 8 guest apartments, bar, dining room, kitchen, storage rooms, and solar installation. The total annual energy requirement is 512 MWh, with power peaks of 150 kW heating and 90 kW cooling. The paper describes the classification of system variants, their evaluation, and the solution for optimization by control and regulating. P.T.H.

A79-38610 Thermodynamic analysis of a solar heating and cooling system equipped with an absorption refrigerator heat pump operating in winter. A. Cocchi (Bologna, Università, Bologna, Italy). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 519-526. 8 refs.

An absorption-refrigeration apparatus operated by solar flat-plate collectors may be more viable economically if the same system can be used as a heat pump during the winter. In this paper, a thermodynamic analysis is presented for a space heating system which employs heat rejected from the condenser-absorber section of a LiBr absorption-refrigeration machine. A mathematical model of the absorption-refrigeration unit based on energy and mass balances provides information on the winter-time efficiency of the apparatus. J.M.B.

A79-38612 Transient behaviour of solar flat plate collectors. A. Arafa, N. Fisch, and E. Hahne (Stuttgart, Universität, Stuttgart, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 549-566. 6 refs. Bundesministerium für Forschung und Technologie Contract No. ET-4045-A.

Three-dimensional steady and transient state heat transfer analyses for a flat plate solar collector are developed to investigate the effect of collector material and design on its performance. These analyses consider the conduction heat transfer along the absorber plate and in case of transient state, also the capacitance distribution. Both analyses have been examined against experimental data giving very satisfactory results. (Author)

A79-38613 Thermal performance of single-pass solar fluid heaters. K.-E. Hassan (Arab Development Institute, Tripoli, Libya) and S. M. Abughres (Alfateh University, Tripoli, Libya). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 569-580.

A mathematical model is set up for solar collectors as a conduction problem with convection to the fluid as a boundary condition. This gives better and more direct insight to the problem than the methods hitherto used, in which the results are obtained by the superposition of solutions established in the literature. The present method gives directly the parameters that control the heat exchange process, and their relative importance. (Author)

A79-38614 Mass production of solar collectors and components (Serienfertigung von Sonnenkollektoren und Komponenten). H. Reusch (Stiebel Eltron GmbH and Co., Holzminde, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 595-611. In German.

The paper describes the production scheme for a plant that turns out 50,000 pieces, or 100,000 sq m in solar collector area, per year. The solar system itself consists of a collector with 2 sq m absorption surface with extruded corrosion-proof aluminum frame, a solar storage unit with 250-1,000 liter capacity, external heat exchanger, and electronic control with 3-point temperature measurement. Market studies showed that only mass production could be profitable. The layout of the factory is described, and the operations are classified as fully automatic and semi-automatic. The sequence of operations for making the absorber and the frame, applying the coating, and assembling the collector, is described. P.T.H.

A79-38615 The air-water collector - Operating experience and utilization possibilities (Der Luft-Wasser-Kollektor - Betriebsergebnisse und Einsatzmöglichkeiten). A. Stork (Ingenieurbüro Stork, Munich, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 1. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 613-620. 10 refs. In German.

A combination air-water solar collector is discussed with attention given to the problems inherent in combining air and water in one collector because of the great difference in their specific heats. Evaluation of collectors and confusion between efficiency and energy yield are also covered. Performance data for an efficient air-water collector is given. Each sq m of collector surface can deliver 15 l/hr of 60 C water, heated from 10 C, while the same area can produce 55 cu m of air per hour at 60 C heated from 20 C. Suggested applications for air-water collectors are a one-family house with electric heating, an agricultural firm that dries hay and grain, a school gymnasium, and industrial drying applications. M.E.P.

A79-38616 Design, operation, and economics of the Energy Plantation as an alternate source of fuels. G. C. Szego, M. D. Fraser, and J.-F. Henry (InterTechnology/Solar Corp., Warrenton, Va.). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 1-15. 10 refs.

An Energy Plantation is a means for producing fuels by collecting and storing solar radiation in plants grown purposely for their fuel value. Appropriate selection of plant species and plantation cultural practices is the key to producing fuels by this means at attractive cost. This paper discusses how the Energy Plantation is designed and operated for maximum productivity of plant material. Also included in the discussion are the equipment requirements and the estimated costs for plantation operation. The cost of the fuel produced is estimated to be between \$1.00 and \$1.50 per million Btu. (Author)

A79-38617 Practical aspects and applications of bioconversion (Aspects pratiques et applications de la bioconversion). J. B. Hasdenteufel (Nice, Université, Nice, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 17-26. In French.

The paper discusses the harnessing of the basic reactions of photosynthesis and microorganism activity for the purpose of industrial production of high energy materials that are easily stored. Some of the processes mentioned include photolysis of water constituents and hydrogen production at low temperature, algae cultivation on lagoon surfaces and reefs, the transformation of these algae into methane by bacterial fermentation, and the production of protein food rich in essential amino acids. P.T.H.

A79-38618 Theoretical and experimental study of a cylindrical solar photochemical reactor (Etude théorique et expérimentale d'un photoréacteur solaire cylindrique). E. F. Jaguaribe, L. Aiache, and J. L. Chevalier (Aix-Marseille III, Université, Marseille, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 41-52. 11 refs. In French.

A critical study concerning concepts and methods often used in the design of photochemical reactors is presented. A theoretical model for a tubular reactor which is placed along the axis of a truncated conical concentrator with a apex angle of 90 deg is proposed. Comparisons between theoretical and experimental results are made. (Author)

A79-38619 New developments and plans for solar power plants of M.A.N.-Company. M. Simon (Maschinenfabrik Augsburg-Nürnberg AG, Munich, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 53-64. 5 refs.

The paper describes the performances of components for solar power plants under development at M.A.N. The energy spectrum and performance ranges vary from 0.5-5 kW/200 C for solar pumps, 5-50 kW/200-300 C for small solar plants, 50-1000 kW/300-400 C for large plants, 1-10 MW/500 C for small steam power plants, and 10-100 MW/800-1000 C for gas-cooled plants. Future studies will concentrate on Stirling engine paraboloids.

P.T.H.

A79-38620 The performance of solar water heating systems with flat plate collectors. E. Bujakowski (Amcor, Ltd., Tel-Aviv, Israel). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 65-71.

The performance of a solar water heating system with flat plate collectors is calculated from the daily total (global) radiation on a horizontal surface and the collector instantaneous efficiency curve. In order to compute, without the aid of a computer, the performance of such a system over a given period of time, an approximate method is proposed.

P.T.H.

A79-38621 Central receiver solar heating system. T. Hammar (Lund, Tekniska Hogskolan, Lund, Sweden). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 73-84. 12 refs.

A computer program for calculating the performance of a solar house heating system in which an auxiliary source provides the heat not provided by the solar heater itself is described in its general features. It is assumed that the auxiliary heater is a conventional boiler that utilizes fossil fuel or electricity. The subprograms are SUN, in which a rectangularly divided random generator is used to simulate the influence of clouds, STORAGE, in which the temperature of a nonstratified storage tank is calculated, SUN COLLECTOR, which calculates the thermal energy transformed from incident solar radiation, AUXILIARY HEATER, in which several ways of connecting the auxiliary heater are considered, and HOUSE, which calculates the heating load. The calculation method is equivalent to a dynamic calculation based on stepwise constant parameters. Some sample calculation results are presented, including the annual load supplied by solar energy as a function of collector area.

P.T.H.

A79-38622 Design of solar heated warm water heating facilities from an economic viewpoint (Auslegung von solarbeheizten Warmwasserbereitungsanlagen nach wirtschaftlichen Gesichtspunkten). P. Schaub and A. Edler (Graz, Technische Universität, Graz, Austria). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 85-98. 5 refs. In German.

A graphical-numerical method is proposed for designing solar-heated warm water heating facilities. The method provides in a simple and clear manner, after obtaining the savings curve and converting it into a cost diagram, the points of maximum profit. The savings curves are obtained through a simulation program. The results can be applied, with the aid of given influence factors, to a good approximation to other cases with similar installation and meteorological conditions.

P.T.H.

A79-38623 One year's experience with a do-it-yourself gravity-driven solar domestic hot water unit (Einjährige Erfahrungen mit einer selbstgebauten, schwerkraftbetriebenen solaren Brauchwasseranlage). H. Schulz (Bayerische Landesanstalt für Landtechnik; Bayern Landtechnik Weihestephana, Freising, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 101-111. In German.

A solar system for domestic hot water was designed and built by do-it-yourself with commercial parts. The system uses gravity and

needs no pumps. It takes about 60 to 80 hours to complete such an installation which serves a family of 3 and costs around 800-1000 DM. In the summer of 1977, despite below-average sunshine, 90% of the domestic hot water was provided from this experimental unit; in spring and autumn it was 60% and in winter 20%. The instructions to build your own solar system are given by papers and courses.

(Author)

A79-38624 LiBr absorption cooling devices as heat pumps. B. Boldrin (CNR, Laboratorio per la Tecnica del Freddo, Padua, Italy), M. Bolzan (Padova, Università, Padua, Italy), and R. Lazzarin (CNR, Laboratorio per la Tecnica del Freddo; Padova, Università, Padua, Italy). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 127-136.

Absorption devices can be utilized as heat pumps, thus satisfying both cooling and heating requirements. The COP and the circulation ratio depend strongly on the cycle temperatures. A 1.7 COP is obtainable: therefore absorption systems look very promising when compared to the traditional heat pumps electrically operated.

(Author)

A79-38625 Influence of storage tank heat exchanger and mass flow rate on collector efficiency of solar heating units (Der Einfluss von Speicher-Wärmetauscher und Durchfluss auf den Kollektorwirkungsgrad solarthermischer Anlagen). P. A. Schoeck (Hoval AG, Vaduz, Liechtenstein). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 137-148. In German.

The interaction between collector and storage tank heat exchanger is investigated. It depends on heat exchange parameters and mass flow rate. Dimensionless parameters are derived which describe the operation condition of the plant in a universal form. A graphical method for determining the operation point is described.

(Author)

A79-38626 Direct-contact heat exchange-storage tank in solar houses (Direkt-Kontakt-Wärmetauscher-Speicher in Sonnenhäusern). W. Loss (Colorado State University, Fort Collins, Colo.). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 149-159. 5 refs. In German.

A pilot plant direct-contact-heat-exchanger-storage-system has been tested with three collector liquids. These liquids were heavier than water and not soluble in water. Heat transfer and fluid dynamics were studied as these liquids streamed through a perforated plate at the top of the unit and passed down through a column of water. A full-scale direct-contact heat exchanger has been constructed and is presently being tested with Colorado State University Solar Houses I and III.

(Author)

A79-38627 Important specification of pyranometers for solar energy applications /Survey article/ (Wichtige Spezifikationen von Pyranometern für Solarenergie-Belange /Übersichtsreferat/). K. Dehne (Meteorologisches Observatorium, Hamburg, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 163-178. 15 refs. In German.

The most important specifications of pyranometers are presented from the viewpoint of instrument engineering and test operations. The relevant limiting values of the WMO classification and the necessary data given by pyranometer manufacturers are pointed out. The effect of angle of inclination on sensitivity is discussed and some error questions are clarified.

P.T.H.

A79-38629 Fast spectral radiometer (Schnelles Spektralradiometer). H. Albrecht, H.-W. Spaude (Stuttgart, Universität, Stuttgart, West Germany), and W. Arndt. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 191-201. 8 refs. In German.

A fast electronically controlled spectral radiometer for measuring the spectral composition of solar radiation is described. The measuring signal is electronically processed. The measuring range is 300-2500 nm with constant bandwidth of 10 nm over the whole measuring range. Measurement rates are up to 100 nm/sec with reproducibility better than 0.1 nm. The instrument can be directed in any way with the aid of a gimbal suspension. The optical and electronic control blocks are described, and some sample global radiation measurements are presented. P.T.H.

A79-38631 Hydrogen production with the ELOFLUX electrolysis cell (Wasserstoffherzeugung mit der ELOFLUX-Elektrolysezelle). H. Ewe and E. Justi (Braunschweig, Technische Universität, Braunschweig, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 247-263. 20 refs. In German.

Hydrogen can be produced inexpensively by means of a compact hydrogen electrolysis cell working on the ELOFLUX principle. The electrodes are porous on the basis of a double skeleton catalyzer design, and concentration differences in the inner part of the electrode and the free electrolyte region are avoided by continuous washing of the porous electrode through the hydrostatic pressure drop. The electrodes are a mixture of carbonyl nickel, Raney nickel with 2 wt.% titanium, and Na₂CO₃ filler, with 80% porosity. At 90 C and a current of 200 mA/sq cm the energy requirement of the cell is 3.75 kWh. P.T.H.

A79-38632 A solar assisted economy. A. G. Potter (Iowa State University of Science and Technology, Ames, Iowa). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 277-290. 10 refs.

A solar energy-assisted economy in which off-peak solar generated electricity is stored for later peaking use or utilized in the production of methanol, methane, or ammonia from hydrogen obtained by electrolysis of water and atmospheric or chemical process carbon dioxide is described. Hydrogen serves only as an intermediate product used for producing peaking power or for fuel synthesis. The system maximizes the use of solar energy in peak period generation and minimizes its use in electrical off-peak loads served by coal or nuclear-generated energy. The on- and off-peak prices paid by the utility per kilowatt hour of solar energy would be adjusted to offset losses due to solar displacement of the electrical load. C.K.D.

A79-38633 Electrolytic hydrogen production by means of solar and wind energy (Production d'hydrogène électrolytique par l'énergie solaire et éolienne). C. da Câmara Tôrres and J. Goldfarb (Paraiíba, Universidade Federal, João Pessoa, Brazil). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 291-299. 8 refs. In French.

The authors propose the production of electrolytic hydrogen through a wind-solar power station, consisting of 5 Darrieus wind generators of 20 kw, a solar tower of 100 kwth, with hydroelectric complementation. During most of the day the electrolysis will be in the vapour phase and during the rest of the time in liquid phase. Studies made to establish the conditions for economic viability of the process arrived at a period of 11 years for recovery of the invested capital. (Author)

A79-38634 A case study of a solar assisted heat pump system - 1977. J. Healey (New York, State University, Albany, N.Y.). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 301-315. 11 refs.

Results from a one year study of an operational solar assisted heat pump (SAHP) system in Albany, New York are presented. This unique heating system was designed and built in 1975-6, and operated and monitored intensively in 1977. This SAHP system heats the State University of New York at Albany Alumni House Conference Center; a two story, wood frame office and conference building with 740 sq m of floor area. The system has 214 sq m of flat plate collectors matched with a water to water heat pump and 30,000 liter water storage. (Author)

A79-38635 Solar-assisted heat pump heating with tube collectors (Solarunterstützte Wärmepumpenheizung mit Schlauchkollektoren). A. Ritter (Max-Planck-Institut für Kohlenforschung, Mülheim an der Ruhr, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 317-323. 9 refs. In German.

Experiments were conducted on the performance of a solar-assisted heat pump heating system operating at nonconstant temperature of the low-temperature heat source. Main elements are an electrically driven heat pump turning out 75,000 kJ at inlet temperature of 283 K. It is connected to a 30 sq m field of parallel connected Aquasun collectors 500 x 50 cm in size, placed on the roof of the building. In the measurement period from January to May, 1978, the heat pump produced 9194 kwh of heating warmth, of which 2776 kwh were needed for electric energy. P.T.H.

A79-38636 Uncovered absorber combined with flatroof collectors and heatpump (Freiliegender Absorberelemente kombiniert mit Flachdachkollektoren und Wärmepumpe). U. Luboschik (Ingenieurbüro für Solartechnik, Eimeldingen, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 329-339. 8 refs. In German.

A heat pump assisted solar heating system is discussed. The system, which heats a 10,000 cu m four-story administrative building in Tuttlingen, West Germany, features 80 sq m of plastic absorber elements, 40 sq m of flat roof collectors and a 3800 liter storage tank. These are backed up by a heat pump with a thermal capacity of 44 kW. In addition, the system is capable of recycling heat from exhausted air. Attention is given to the operation during various conditions: sunny weather below or above freezing, poor weather above freezing, minimal irradiation below freezing, and summertime. It is expected that the heat pump will be able to contribute heat to the system at temperatures above -6 C. Principal operating range will be from 3-13 C and the estimated yearly operation will be 1000-1200 hr/yr. It is concluded that as long as there does not exist a method of storing summer heat for winter use, heat pumps will have to be employed as backup systems. M.E.P.

A79-38637 Storage of solar energy at low temperatures through chemical processes (Speicherung von Sonnenenergie bei niedrigen Temperaturen durch chemische Prozesse). F. W. Reiter (EURATOM and Comitato Nazionale per l'Energia Nucleare, Centro Comune di Ricerche, Ispra, Italy). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 341-348. 5 refs. In German.

Two chemical reactions are presented for short-term storage of solar energy, namely the double conversion of reciprocal salt pairs and the formation and decay of double salts with simultaneous loss and uptake of water of crystallization. For both reactions an experimental example is given. (Author)

A79-38638 Study on room heating utilizing eutectic salt mixture. N. Yoneda and S. Takanashi (Tokyo, Science University, Noda, Japan). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 349-359.

Through studies of phase change between solid and liquid, an inorganic eutectic mixture, $Mg(NO_3)_2 \cdot 6H_2O / MgCl_2 \cdot 6H_2O$ has been developed as a heat storage material. Using this mixture, a room heating system involving a heat storage tank and a simple solar collector has been studied; the feasibility of such a system has been evaluated; and problems which will be encountered in the course of development have been examined. B.J.

A79-38639 The development of a storage system based on encapsulated p.c.m.-materials. E. van Galen and C. den Ouden (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Technisch-Physische Dienst TNO, Delft, Netherlands). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 363-372. 5 refs.

This article describes the design of a first prototype of a short term storage system, based on phase-change material encapsulated in a polymer construction. Some measurements of the thermal behavior of this storage system are given. (Author)

A79-38640 An experimental study of walls with latent heat for residences (Etude expérimentale de parois à chaleur latente pour l'habitat). L. Bourdeau, A. Jaffrin (CNRS, Laboratoire d'Écothermique Solaire, Nice, France), and A. Moisan (Concepcion, Universidad, Casilla, Chile). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 373-404. In French.

Three types of walls containing chliarolith (calcium hexahydrate chloride and a stabilizer) have been developed for collection, stockage, and distribution of solar energy in apartments. Two walls with separate reception and storage were investigated. The first is a flooring arrangement which utilizes water as the heat transfer fluid; hot water from the solar collectors transfers its heat to the floor by way of the chliarolith heat filter. The second is a vertical partition which acts as a thermal diode. The external face collects solar radiation and the inner face stores and distributes it. The third version investigated is basically a Trombe type wall with the cement layer replaced by chliarolith. The heat transfer characteristics of prototypes of these walls have been determined experimentally and theoretically. C.K.D.

A79-38641 'Chemical heat storage pump' - Storage and utilization of solar energy through reversible chemical reaction in vacuum systems on the example of the system $CaCl_2 \cdot H_2O$ ('Chemische Wärmespeicherungspumpe' - Speicherung und Nutzung von Solar-energie durch reversible chemische Reaktion in Vakuumsystemen am Beispiel des Systems $CaCl_2 \cdot H_2O$). D. Brodalla, D. Hollenberg, and R. Kniep (Düsseldorf, Universität, Düsseldorf, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 405-414. 9 refs. In German.

A79-38642 Standards and testing criteria for solar systems and components in the United States. J. T. Pytlinski and R. L. San Martin (New Mexico State University, Las Cruces, N. Mex.). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 415-434. 50 refs.

The status of the development of standards and testing criteria for solar systems and components in the United States is presented on the base of present and projected market demand. The development mechanism of testing and standards is illustrated schematically.

Performance criteria and testing procedure for solar collectors and photovoltaic cells are described in detail. Schematics of standard testing stands for water and air collectors are given. Outdoor testing versus indoor testing under simulated solar radiation is discussed.

(Author)

A79-38643 Solar collector tests in Rwanda. F. Kalos (Centre d'Etudes et d'Applications de l'Energie au Rwanda) and P. Mpawenayo (Université Nationale du Rwanda, Butare, Rwanda). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 439-449.

A simple method for testing collector performance is described. It consists of maintaining steady the inlet and outlet temperatures and adjusting the water flow rate throughout the day depending on the intensity of radiation. A multiple regression analysis of the hourly mean values yields a set of collector parameters. The introduction of a time constant in the analysis permits to carry out the tests even with intermittent insolation. (Author)

A79-38644 Investigations of glass collectors with radiation absorbing heat carrier (Untersuchungen an Glas-Kollektoren mit Strahlung-absorbierendem Wärmeträgermedium). R. Beer, U. Kutz, J. Plagge, and H. Weik (Lübeck, Fachhochschule, Lübeck, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 451-461. 5 refs. In German.

Tests were made with a flat plate energy converter consisting of a triple glass plate unit forming two combined thin compartments. The front compartment is utilized for thermal isolation while the rear compartment is filled with a black radiation absorbing fluid acting as the photothermal converter. Efficiency curves of the collector taken under laboratory and under real solar conditions are being presented. (Author)

A79-38645 European solar collector development and testing - A commercial view. P. D. Gillespie and R. Hegenbart (Franklin Institute GmbH, Munich, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 463-468a.

Conditions surrounding the development of solar flat plate collectors in Europe are identified along with the criteria manufacturers must meet satisfactorily in order to encourage applications of solar technology in habitat heating and cooling systems. Two European wide surveys, one yielding technical descriptions of 140 collectors and the second, an analysis of European needs for test facilities are reported. It appears that over half of the manufacturers are not able to measure the effectiveness and potential lifetimes of their collectors, and require such testing support for further development and marketing plans. (Author)

A79-38646 Analysis of the economic potential of solar thermal energy to provide industrial process heat in the United States. G. C. Szego and M. D. Fraser (InterTechnology/Solar Corp., Warrenton, Va.). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 469-481. Contract No. EY-76-C-02-2829.

An analysis was made of the potential applications of solar thermal energy to provide process heat for industry in the U.S. The important characteristics, including performance and cost, of various solar thermal energy systems were identified, summarized, and compared. An industrial process heat data base was developed with detailed information, including temperature, on heat used in specific applications. These data were analyzed to identify feasible solar process heat applications. This quantitative assessment indicated a maximum potential of solar process heat of 0.6 quadrillion Btu (0.6 quadrillion kJ) per year in 1985, and 7.3 quadrillion Btu (7.7 quadrillion kJ) per year in 2000. (Author)

A79-38647 A preliminary feasibility study into the use of solar energy to provide year-round heating for a factory unit. I. C. Ward (Sheffield, University, Sheffield, England). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 483-508. 8 refs.

A preliminary study of the use of a solar assisted heating system for a factory unit is outlined, noting the usefulness of large areas of roof space which can be utilized for solar collection. Criteria for the design of the factory building with its costs and methods of thermal calculation are discussed. The solar assisted heating system design calculations and seasonal operating cycles are described. A comparison of the running costs of the conventional factory system with an oil-fired warm air heating plant, a highly insulated factory with a warm air heating plant, and a solar assisted heat pump shows that the latter does not have pronounced seasonal changes in running costs since only 20% of the electrical input drives the compressors, the rest being used for fan power which is independent of the heating requirement. It is concluded that it is possible to construct a commercially viable unit by using reverse cycle heat pump units in conjunction with low temperature collection of solar energy with inter-seasonal storage. A.T.

A79-38648 Continuous solar-heated absorption cooling unit for industrial applications. I. Borde, M. Jelinek, and I. Yaron (Negev, University, Beersheba, Israel). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 511-521. 9 refs.

Absorption refrigeration installations, using R22-absorbent systems appear to be attractive for continuous industrial refrigeration applications, notably for sea water desalination. These systems are expected to be able to utilize low thermal-potential energy sources, particularly solar energy, to stably operate within a broad range of operating conditions using conventional machinery, and in many cases to provide efficient cooling by direct thermal contact with the refrigerant. (Author)

A79-38649 Utilization of solar-derived heat in industrial processes (Utilisation de la chaleur d'origine solaire dans les processus industriels). F. Moisan (CNRS, Paris, France). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 2. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 523, 525-535. In French.

A study of industrial uses of heat in different energy ranges showed that 40% of French industries using heat required temperatures below 300 deg C, the range identified as suitable for applications of solar technology. The use of solar energy to supply heat requirements of three branches of industry, textile industries, paper industries, and food processing industries, has been investigated. In particular, the heat requirements for different processes in the food industry were examined. The fruit canning industry was selected for further study of solar energy applications because of its temperature requirements (less than 130 deg C), operation during the period of maximum insolation, and location in the south of France. An economic analysis is presented for three solar systems: a system with 4500 sq m of collector surface and optimal storage of 5000 therms, supplying 1/3 of the energy consumed by the plant; a system with 8500 sq m of collector surface and optimal storage capacity of 13,000 therms, supplying 1/2 the energy consumed; a system with 18,000 sq m of collector surface and optimal storage of 40,000 therms, supplying large amounts of excess energy for resale. C.K.D.

A79-38650 A low energy house in Sweden heated by a solar energy system with heat pump. T. V. Esbensen and M. Mikkonen. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 17-22.

A79-38651 The design of four solar houses in Zoetermeer, The Netherlands. C. den Ouden (Centrale Organisatie voor Toegepast-Natuurwetenschappelijk Onderzoek, Technisch-Physische Dienst TNO, Delft, Netherlands). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 35-44.

This paper describes the design of four solar houses. The problems raised during the design-phase are discussed as well as the approach to solve these problems. A description of the technical aspects of the four different solar heating installations is given. The effect of the various energy saving measures is given, including the calculated energy to be collected with the solar heating installation. Finally a few results of the measured data during the first few months of the 2-year measuring and evaluation program have been discussed. (Author)

A79-38652 The LN solar/heat pump house at Skive, Denmark. A. Eggers-Lura (International Solar Power Co., Ltd., Gentofte, Denmark). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. (A79-38576 16-44) Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 45-56.

The paper describes the experimental LN solar/heat pump house, which was completed at Skive, Denmark in July 1977. A technical description is rendered of the house and its solar heating installation. Figures are given for the economics of the house, both in terms of 'energy economy', and the experiences that have so far been gained on operation of the house are briefly described. (Author)

A79-38653 Performance study of a solar still in Valencia /Spain/. J. Riera, J. A. Martinez-Lozano, F. Tejerina, and F. Tena (Valencia, Universidad, Valencia, Spain). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 57-71. 8 refs.

An experimental study of a solar water distillation process was carried out in Valencia, Spain. Two stills were studied: (1) a low thermal inertial still provided with a floating absorber, and (2) a convection still. The low thermal inertia still had a production over 4% higher than the conventional still. The relationship between production and other parameters was derived, leading to an estimate for the annual production at Valencia. P.T.H.

A79-38654 Potential applications of solar furnaces in materials industry. D. Suresh (Indian Institute of Science, Bangalore, India) and P. K. Rohatgi (Council of Scientific and Industrial Research, Trivandrum, India). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 107-127. 44 refs.

The paper gives a review of possible applications of solar furnaces for materials processing. The discussion covers mineral processing and extractive metallurgy applications, installations for purification of refractory oxides, studies on stabilization of refractory, vaporization studies in a solar furnace, solar welding and brazing, crystal growth in a solar furnace, solar furnaces for combustion research, and solar chemical reactors. A solar furnace for supplying heat for producing solar cell ribbon in space is depicted. P.T.H.

A79-38655 Further development of the high-speed converter with flapping hinge /Goslich system/ - Plans for application in developing countries (Weiterentwicklung des Schnellläufer-Konverters mit Schlaggelenken /System Goslich/ - Anwendungsplanung für Entwicklungsländer). H. D. Goslich (Ingenieurbüro Hans-D. Goslich, Hamburg, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 141-155. In German.

This report refers to the development and construction of the blades of the 70 kW twin rotor wind power plant on Sylt and the two-blade high-speed rotor plant presented to the Solar Forum 1977. It describes three blade rotor configurations with different blade starting position due to different spring preloading characteristics and over-all running behavior of the entire rotor system. The advantage of applications of the wind power plant system Goslich in developing countries is shown. (Author)

A79-38656 Design analysis of a vertical axis wind turbine. L. F. Jesch and D. Walton (Birmingham, University, Birmingham, England). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 157-168. 9 refs.

Aerodynamic and structural design analysis of a Darrieus rotor is presented. The computer model uses published experimental data for the NACA 0012 aerofoil. The analysis of the relative contributions of the troposkien blade elements leads to a suggested cutting off parts of the blade which widens the useful velocity range. The effects of blade numbers on performance and stresses are analyzed. (Author)

A79-38657 Total wind energy over Central Europe and its maximum utilization through optimal degree of development of solar wind conversion plants (Die Bruttowindenergie über Mitteleuropa und ihre Maximale Nutzung durch optimalen Ausbaugrad der Windkraftwerke). W. Mayer-Schwinning (Technisch-wissenschaftliche und technisch-wirtschaftliche Planungen und Beratungen, Bad Homburg, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3.

Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 169-185. In German.

An evaluation of wind data from 50 measuring stations and 5 most measurements throughout Central Europe over a many-year period was carried out in order to obtain an estimate of the average available wind energy per year in this region. The estimate is based on a formula expressing the specific total wind energy per year as 11.63 times the cube of the mean yearly wind speed. Through an imaginary wall 400 m high running from north to south across Germany there would flow a total yearly wind energy of about 400 billion kWh. Only about 25-30% of this energy can be tapped. An optimal network of wind converters would yield 30,000 billion kWh per year, or over 100 times the current energy requirement. P.T.H.

A79-38658 Test report and power measurement on a 200-watt wind generator (Erfahrungsbericht und Leistungsmessung an einem 200-Watt Windgenerator). F. Auer (Frankfurt, Universität, Frankfurt am Main, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 189-193. In German.

The paper reports on output power measurements on a 15 V/200 W small wind generator with quadrupole dc generator and two-blade wood rotor with a diameter of 1.9 m. A series of measurements was averaged to yield the curve for the power output as a function of wind velocity. The windmill delivers power starting from a wind speed of 3 m/sec. From there the curve rises according to a power law and levels off at 10 m/sec with 100 W. The output is short of the theoretical output based on the proportionality of output to the third power of wind velocity, and the shortfall is probably due to the presence of gusts. P.T.H.

A79-38659 Solar heating of sports centers in Belgium - Chevetogne and Butgenbach. A. Grosfils, G. G. Descy, and M. De Maubeuge (Engineering Office ATRAC, S.A., Brussels, Belgium). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 217-226.

The paper describes briefly the solar thermal systems planned for two sports centers in Belgium. The first center includes among its thermal load sources an outdoor olympic swimming pool, an indoor pool, a sports hall, two bars, a meeting hall, and assorted shops. One set of collectors heats the outdoor pool or the storage, while the other set of collectors heats the boilers and one pool or storage. Heat pumps are used to upgrade the energy at low temperature. Simulations show annual thermal needs of 1800 MWh, which can be covered 62% by solar energy. The other sports center is smaller and has an artificial lake for use as constant thermal source for a heat pump. P.T.H.

A79-38660 Description of solar energy activities and results at Arsham H.T.T. College. A. Pirouzan and N. Fariborzi (Arsham HTT College, Kerman, Iran). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 229-246.

The paper outlines some of the problems in the solar energy design of 6 buildings for a college in Kerman, Iran, where the diurnal temperature range can be as great as from 18 to -12 C. The collector developed was such that galvanized pipes and fittings could be used so that welding and handling of the water circulation system could be managed by manpower already available at the town. The mass produced collectors consisted of glass, welded pipe, black plate, fiberglass insulation, and frame. P.T.H.

A79-38661 Wind energy ships - Potential for modern wind-driven sea transport systems (Windenergie-Schiffe - Möglichkeiten moderner windgetriebener Seetransport-Systeme). P. Schenzle (Hamburg, Universität, Hamburg, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 325-345. 18 refs. In German.

The paper reviews some new sailing principles and presents the results of analyses of the potential speeds for some new types of large wind-driven sea transport systems based on these new principles. Attention is focused on the multimast DYNA ship for which wind tunnel data are available. Results of speed prediction studies are presented, showing the effects of different parameters on speed for different wind conditions. P.T.H.

A79-38662 Wind energy plants for electric generation - Economic significance and example (Windenergieanlagen zur Stromerzeugung - Wirtschaftliche Bedeutung und Fallbeispiel). G. Purper (Battelle-Institut, Frankfurt am Main, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 377-387. In German.

Although wind energy on a large scale does not seem economically feasible at present, it does offer a good solution in areas where the electric power requirements are largely coincident with the available wind energy and where the costs of competing sources are more expensive in the long run. The decentralized power generation provided by wind energy has the advantages of being less vulnerable, safer in the environmental sense, and offering a measure of autonomy to the user. A brief description is given of operations at a wind conversion plant that serves exclusively the power needs of a Westphalian farm. The wind comes in general from two directions, the mast has a height of 11 m, the blades are adjustable, electricity is produced in the range 35-85 rev/min, and the generator produces 6 kW/110 V. The current is stored in 60 batteries of 216 A-h capacity. P.T.H.

A79-38663 Guaranteed power /capacity effect/ and total power as defining parameters of wind conversion system energy production (Garantierte Leistung /Kapazitätseffekt/ und Gesamtleistung als Bestimmungsgrößen der Energieproduktion eines Windkraftwerks). L. Jarass (Regensburg, Universität, Regensburg, West

Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 389-402. In German. Bundesministerium für Forschung und Technologie Contract No. ET-4085-A.

Guaranteed power, to determine the capacity effect, and total power, to determine annual energy production, are defined for wind conversion systems as measures of economic performance for comparison with conventional and alternative energy systems. The discussion goes into the relationship between guaranteed power, total power, installed power, planned and unplanned loss of load of conventional and unconventional power plants, storage size, yearly average wind velocity, nominal rotational frequency, and rotational frequency variations. P.T.H.

A79-38664 Legal and economic aspects of engineering design in solar water heating systems. L. F. Jesch, P. Soldatos (Birmingham, University, Birmingham, England), and A. S. Daniel (West Midlands County Council, England). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 415-428. 12 refs.

The United Kingdom laws which control the solar hot water trade through the Trading Standards Departments are described, noting the law enforcement methods and difficulties in their enforcement due to the complexity of the subject and lack of experts with the necessary qualifications to evaluate validity of solar system performance claims. The economics of solar water heating in the United Kingdom are reviewed, considering the economic optimization in relation to the environment and comparison of the costs and benefits with the conventional alternatives. It is concluded that commercially available domestic systems can hardly compete with the existing conventional gas and electric systems. The optimal condition does not represent net savings over the expected life of the system which places severe limitations on advertisements. Noncompliance with the law can have serious consequences, but some companies successfully evade penalties. A.T.

A79-38665 Architectural planning - The possibility of using solar energy must be kept open (Bauleitplanung - Möglichkeit zur Sonnenenergienutzung muss offengehalten werden). U. Grote. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 429-436. In German.

The design of buildings should leave open the option for installing solar energy equipment, even if such installation comes after the building is constructed. A proposal for implementing this idea in developing countries is made. An integrated construction plan, land allocation, and cultivation procedure is proposed. P.T.H.

A79-38666 Energy supply for the Federal Republic on a regenerative basis (Energieversorgung der Bundesrepublik auf regenerativer Basis). H. Seitz (Oldenburg, Fachhochschule, Oldenburg, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 437-440. In German.

Conditions for a practical implementation of regenerative energy supply for the FRG are outlined. An energy system with regenerative sources where two-thirds of the energy is produced in the country appears possible after a long transition period. In the transition period, half of the one- and two-family dwellings will be provided with heat through collectors. P.T.H.

A79-38667 Potential for use of solar energy in private households to the year 2000 (Einsatzpotential der Solarenergie in den privaten Haushalten bis 2000). H. Klais (Institut für Kernenergetik und Energiesysteme, Stuttgart, West Germany), J. Nitsch, and T. Schott (Deutsche Forschungs- und Versuchsanstalt für

Luft- und Raumfahrt, Stuttgart, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 441-455. 12 refs. In German.

An estimate is made of the use potential for solar energy systems and the resulting energy savings for the time frame 1974-2000. On the assumption of a linear strategy for introducing solar energy systems to achieve a yearly market quota of 35% in the year 2000, a savings of 34.4 TWh per year in private households is estimated. P.T.H.

A79-38668 Aspects of solar energy use in the Federal Republic of Germany (Aspekte der Sonnenenergienutzung in der Bundesrepublik Deutschland). M. Meliss (Kernforschungsanlage Jülich GmbH, Jülich, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 457-472. In German.

The paper summarizes the potential applications of solar energy. The focus is on the substitution potentials of solar technologies that can be implemented in the Federal Republic of Germany. Current national and international activities in the field of solar energy utilization are outlined, and some R&D plans of the atomic research establishment Jülich are detailed. (Author)

A79-38669 Conditions for the use of solar energy (Voraussetzungen der Sonnenenergienutzung). P. A. Fornallaz (Eidgenössische Technische Hochschule, Zurich, Switzerland). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 473-488. 14 refs. In German.

The primary goal of a solar-based energy policy is the realization of a lasting cyclical economy in place of the present-day short-term continuous economy. Solar energy therefore must not be restricted to a supplementary role. Some principles for future solar energy utilization are announced, pertaining to the economic evaluation of the solar energy and environmental factors. An essential point concerns the need for stabilizing energy demands and proper allocation of sources for producing different types of energy. P.T.H.

A79-38670 Energy analysis of low-temperature solar energy systems (Energetische Analyse von Niedertemperatur-Sonnenenergieanlagen). H. J. Wagner (Kernforschungsanlage Jülich GmbH, Jülich, West Germany). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 491-501. 7 refs. In German.

An energy analysis compares the primary energy savings achieved through use of three selected solar energy systems for domestic hot water and heating for one-family houses with the energy costs for constructing the required system components. The analysis method is a combination of process chain analysis and input-output analysis. The effects of different growth rates on the load of the primary energy budget are calculated. P.T.H.

A79-38671 Retrofitting strategies for a housing cooperative. K. McCartney. In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 503-511. 8 refs.

An outline of the strategies which might be adopted by a Housing Cooperative which wishes to incorporate solar water heating systems in their building programme despite tight financial constraints. Reference is also made to some of the design implications of particular strategies. (Author)

A79-38672 Solar energy systems and life cycle cost. W. S. Fleming (W. S. Fleming and Associates, Inc., Fayetteville, N.Y.). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 519-533. 7 refs.

This paper discusses the economic problems and benefits of solar energy systems. Various systems, geographic areas, and capital expenditures are discussed. The economic justifications are presented in relation to (1) data collection, (2) quantified (statistical data) ROI and payback, (3) qualified economic analysis, and (4) solar energy and economic justification. (Author)

A79-38673 Design of a public exhibition building to demonstrate air, water, and passive solar heating systems. L. M. Brown, J. Krause, B. Crabe, and L. DeDivitiis (Ontario Science Centre, Don Mills, Ontario, Canada). In: International Solar Forum, 2nd, Hamburg, West Germany, July 12-14, 1978, Reports. Volume 3. Munich, Deutsche Gesellschaft für Sonnenenergie, 1978, p. 537-557.

The solar house at Ontario Science Center in Canada is studied. The house, intended to familiarize the general public and students with solar technology, accommodates four separate heating systems, each with its own storage. The systems consisting of, a flatplate water system, an evacuated tube system, an air collection system, and a passive greenhouse effect system which includes 'beadwalls' as the 'main glazing', are detailed. An educational program outline showing how the houses' features are presented to visitors is examined. An additional feature of the water system is the facility to connect a collector supplied by a school or college group for evaluation. In addition, a proposed computer-based instrumentation system which will store data on the amount of insolation, storage temperature, inlet and outlet collector temperatures and flows, is discussed. M.E.P.

A79-38806 Radiation-catalyzed ortho-to-para transition in solid tritium. J. R. Gaines (Ohio State University, Columbus, Ohio), R. T. Tsugawa, and P. C. Souers (California, University, Livermore, Calif.). *Physical Review Letters*, vol. 42, June 18, 1979, p. 1717-1719. 8 refs. Contract No. W-7405-eng-48.

The ortho-to-para conversion time in solid tritium has been measured by NMR techniques. The observed rate is at least ten times faster than the temperature-independent self-conversion in solid H₂ and increases exponentially as the temperature decreases, e.g., the 1/e times are 490 min at 22.5 K and 64 min at 9.1 K. Because of the analogous situation in solid H₂, where atomic H is created when the solid is irradiated, it appears that in T₂, the T atoms are the most likely catalysts for the ortho-para conversion. (Author)

A79-38863 Methods of reducing harmful emissions from thermal power stations. L. I. Kropp (Vsesoiuznyi Nauchno-Issledovatel'skii Teploekhnicheskii Institut, Moscow, USSR). (*Teploenergetika*, vol. 25, no. 11, 1978, p. 2-7.) *Thermal Engineering*, vol. 25, no. 11, 1978, p. 1-6. 7 refs. Translation.

Methods of reducing pollution from the use of various fuels at thermal power stations are presented with the output of pollutants, fly ash, sulfur oxides and nitrogen oxides from various coals tabulated, and sulfur dioxide discharges by all thermal power stations calculated for the years 1975 through 1990. The economics of desulfurization by producing sulfur-free oil at refineries by hydro-cracking, cleaning of flue gases at power stations by the magnesite method, and pressure gasification at power stations are discussed. The methods of reducing sulfur dioxide discharges by removing pyrites from the fuel in the coal pulverization system, and by the use of fluidized beds with alkali additions are described. Emission of nitrogen oxides from the combustion of various fuels is tabulated, and it is noted that design and operational methods can considerably reduce the output of nitrogen oxides produced by oxidation of air and combustion of fuel. Pollution by solids such as ash and incompletely burned fuel is discussed in connection with the

insufficient reliability and stability of operation of electrostatic precipitators, and the required improvements in their design and operation are described. A.T.

A79-38864 Investigating the formation of oxides of nitrogen when burning solid fuel. I. N. Shnitser, L. V. Iur'ev, L. K. Solov'ev, and V. V. Litovkin. (*Teploenergetika*, vol. 25, no. 11, 1978, p. 8-12.) *Thermal Engineering*, vol. 25, no. 11, 1978, p. 7-11. 8 refs. Translation.

A study of the mechanism of the formation of nitrogen oxides with simultaneous investigation of the aerodynamics, the nature of gas formation and the combustion process was carried out in the furnace chamber of a TPP-312A boiler in a 300 MW unit designed to burn Donetsk gas coal screenings with wet bottom ash removal. The layout of the boiler, and the burner arrangement are depicted, and design characteristics tabulated. The NO_x concentration was determined at various cross-sections at the level of the horizontal plane of the burner axis, at specified distances from the burner exits and along the height of the chamber, and at the point of measurement of the balance excess air at the furnace exit. The flue gases were analyzed for NO_x by a linear colorimetric method using the UG-2 gas analyzer. Composition of the furnace gases and temperatures were plotted for the various furnace locations, and it was noted that the concentration fields of the furnace gases, including that of NO_x, level out in the vertical section of the flame where active combustion is observed over the entire cross section, and that the NO_x field levelled out almost entirely in all investigated furnace cross sections above the height of 16,800 mm. The NO_x curves remain practically constant over the furnace height, and the maximum NO_x concentration of 0.7 g/cu m is found at a distance of 8 to 10 m from the burner port, remaining practically the same over the entire furnace chamber. A.T.

A79-38865 An investigation of the formation of oxides of nitrogen in a pulverised coal flame. V. R. Kotler, G. V. Lobov, and V. N. Verzakov (Vsesoiuznyi Nauchno-Issledovatel'skii Teploekhnicheskii Institut, USSR). (*Teploenergetika*, vol. 25, no. 11, 1978, p. 12-15.) *Thermal Engineering*, vol. 25, no. 11, 1978, p. 12-15. Translation.

A79-38869 Heat transfer in a high temperature combustion chamber with premixing. Ia. S. Zhulodov (Akademiia Nauk Ukrainsoi SSR, Institut Elektrodinamiki, Kiev, Ukrainian SSR). (*Teploenergetika*, vol. 25, no. 11, 1978, p. 81, 82.) *Thermal Engineering*, vol. 25, no. 11, 1978, p. 63, 64. Translation.

An investigation of heat transfer with premixing of combustible and oxidant is presented. The primary data for analyzing heat transfer are the distribution of heat fluxes over the length of the chamber and the temperature of the lining. The heat flux distribution shows a characteristic maximum in the first section of the chamber apparently due to the increase in the emission properties of the reacting gas, reradiation of the lining of the front and to recirculating vortices. After the initial surge heat transfer stabilizes and the local dip in the curve is caused by air blast and the seeding. The results of averaging the measured heat fluxes show that the strongest factor for the heat transfer characteristics are the gas temperatures determined by the degree of oxidant enrichment. The integral thermal efficiency of the chamber was determined from the heat flux measurements and its dependence on the composition of the oxidant and the load of the chamber was plotted. A.T.

A79-38871 Pulverized-coal combustion and gasification. Theory and applications for continuous flow processes. Edited by L. D. Smoot (Brigham Young University, Provo, Utah) and D. T. Pratt (Utah, University, Salt Lake City, Utah). New York, Plenum Press, 1979. 350 p. \$39.50.

A collection of review articles on analytical modeling of coal reaction processes is presented, with emphasis on processes utilizing finely pulverized coal entrained in a gaseous phase. Topics include

turbulent and laminated reacting multiphase systems, gas-phase combustion, mechanisms and kinetics of pollutant formation, gas-particle conductive interactions, and mathematical models of one- and multidimensional systems. Appendices provide conversion factors and physical parameters for prediction of transport coefficients, and give the derivations of a four-flux radiation model and Eulerian finite-difference equations. C.K.D.

A79-38876 Annual Simulation Symposium, 11th, Tampa, Fla., March 15-17, 1978, Record of Proceedings. Symposium sponsored by SCS, IEEE, and ACM. Edited by P. N. Adams, E. W. Hawes, Jr., and R. A. Pierce. Tampa, Fla., Annual Simulation Symposium; Long Beach, Calif., IEEE Computer Society, 1978. 358 p. \$20.

Applications of simulation technology to solar energy systems, data processing, scene editing of Landsat imagery, avionics for general aviation aircraft, parachute drop accuracy, terrain displays, and microcomputers for digital missile guidance and control systems are described. Topics of the papers include simulation languages, stochastic simulation of solar energy heating systems, an interactive decision analysis system for assessing the prospects of photovoltaic energy conversion, a simulation of NASA data system needs for the 1985-1990 period, design of a no-critical-element team architecture for future general aviation aircraft avionics, and predictions of demand for general aviation aircraft. J.M.B.

A79-38877 * Contribution to solving the energy crisis - Simulating the prospects for low cost energy through silicon solar cells. A. Kran (IBM East Fishkill Laboratories, Hopewell Junction, N.Y.). In: Annual Simulation Symposium, 11th, Tampa, Fla., March 15-17, 1978, Record of Proceedings. Tampa, Fla., Annual Simulation Symposium; Long Beach, Calif., IEEE Computer Society, 1978, p. 1-19. Contract No. NAS7-100.

PECAN (Photovoltaic Energy Conversion Analysis) is a highly interactive decision analysis and support system. It simulates the prospects for widespread use of solar cells for the generation of electrical power. PECAN consists of a set of integrated APL functions for evaluating the potential of terrestrial photovoltaics. Specifically, the system is a deterministic simulator, which translates present and future manufacturing technology into economic and financial terms, using the production unit concept. It guides solar cell development in three areas: tactical decision making, strategic planning, and the formulation of alternative options. (Author)

A79-38878 A discrete, stochastic simulation model for the analysis and design of solar energy heating systems. G. F. Lameiro (Solar Energy Research Institute, Golden, Colo.) and R. A. Rademacher (Colorado State University, Fort Collins, Colo.). In: Annual Simulation Symposium, 11th, Tampa, Fla., March 15-17, 1978, Record of Proceedings. Tampa, Fla., Annual Simulation Symposium; Long Beach, Calif., IEEE Computer Society, 1978, p. 21-36. 12 refs.

This paper presents a stochastic simulation approach to the generalized solar energy space heating performance analysis and design problem. Specifically, Markov chain models are developed to represent ambient temperature, insolation, hot water load and system performance. From the Markov transition probability matrices for these variables, long-term expected performance is calculated. The theoretical development is implemented in FORTRAN IV on a Control Data 6400 Computer System. Computational experience gained, using the stochastic solar energy systems model, indicates the stochastic approach requires significantly less time than is necessary for standard dynamic deterministic simulation approaches with comparable performance results. In fact, production simulation runs to model the performance of a solar energy heating system for a half year can be done with the stochastic approach in about 10 CPU seconds. (Author)

A79-38888 * Wind turbines for electric utilities - Development status and economics. J. R. Ramler and R. M. Donovan

(NASA, Lewis Research Center, Cleveland, Ohio). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0965*. 19 p. 15 refs.

The technology and economics of the large, horizontal-axis wind turbines currently in the Federal Wind Energy Program are presented. Wind turbine technology advancements made in the last several years are discussed. It is shown that, based on current projections of the costs of these machines when produced in quantity, they should be attractive for utility application. The cost of electricity (COE) produced at the busbar is shown to be a strong function of the mean wind speed at the installation site. The breakeven COE as a 'fuel saver' is discussed and the COE range that would be generally attractive to utilities is indicated. (Author)

A79-38889 # Flowfield measurements in the vicinity of the rotor of a 10 kw windmill. R. L. Figard and J. A. Schetz (Virginia Polytechnic Institute and State University, Blacksburg, Va.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0969*. 8 p. Research supported by the U.S. Department of Agriculture.

A three-pronged study of the flowfield immediately behind the rotor of a 10 kw, horizontal-axis windmill is presented. The predictions of a computerized, blade-element analysis and the scaled results of wind tunnel tests of a 1/5th scale model are compared with field measurements taken with the full-scale unit. In addition, turbulence measurements taken in the field and in the wind tunnel tests are given. Both the analytical predictions and the scaled wind tunnel results agree with the field data to within 10% for total power and the axial velocity profile behind the rotor. (Author)

A79-38890 # Energy conservation and solar energy - Partners in progress. M. B. McCarley (Tennessee Valley Authority, Chattanooga, Tenn.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0979*. 12 p.

Energy conservation and energy use education programs undertaken by the Tennessee Valley Authority (TVA) are discussed. These include a home insulation program, a commercial and industrial energy audit program designed to help detect areas in which conservation measures can be applied, a program intended to encourage use of electric heat pump units, and a project in which the TVA works with builders to encourage construction of energy-efficient homes. In addition, TVA programs involving installation of solar water heaters with off-peak electrical backup in Memphis, a wood heating demonstration project in North Georgia, and installation of a Rankine Heat/Cool Solar Assist Pump system are described. The importance of implementing both energy conservation measures and research and development related to renewable energy resources is stressed. C.K.D.

A79-38891 * Photovoltaic systems perspective. P. D. Sutton (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and G. J. Jones (Sandia Laboratories, Albuquerque, N. Mex.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0983*. 9 p. 11 refs. U.S. Department of Energy Contract No. DE-AC04-76DP00789.

This paper summarizes the elements of photovoltaic power system and clarifies the terminology currently used. The relationship of system efficiency and cost is described particularly for the Balance of Photovoltaic System (BOPS) area. The current status of the BOPS development activity is described. The photovoltaic systems terminology is found to be on the road to standardization. Power conditioning, energy storage, and support structure are found to be BOPS cost and/or efficiency drivers. Although the current BOPS activity has identified low-cost/high-efficiency components, further development work is necessary. (Author)

A79-38892 * Summary results from the NASA Tech House one year live-in. I. L. Hamlet (NASA, Langley Research Center, Energy and Environmental Management Section, Hampton, Va.).

American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0987. 9 p. 5 refs.

The NASA Tech House was designed and constructed at the Langley Research Center, Hampton, Va., to demonstrate and evaluate new technology potentially applicable for conservation of energy and resources and for improvements in safety and security in a single-family residence. All technology items, including solar energy systems and a waste water reuse system, were evaluated under actual living conditions for a one-year period with a family of four living in the house in their normal life style. Results are presented which show overall savings in energy and resources compared to requirements for a defined similar conventional house under the same conditions. Also included are general operational experience and performance data for all the various items and systems of technology incorporated into the house design. (Author)

A79-38893 # Rough cost estimates of solar thermal/coal or biomass derived fuels. R. J. Copeland (Solar Energy Research Institute, Golden, Colo.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-0988. 7 p. 9 refs.*

Approximate costs of producing synthetic methane by a hybrid process combining solar thermal energy with coal or biomass starting material are calculated parametrically. The solar thermal heat source considered is a central receiver system assumed to be located in a region of the Southwest with direct insolation of 6.9 to 7.3 kWh/sq m-day. Cost ranges considered for plant startup in 2000 are: coal, \$1.26-3.26/MBtu; biomass (from residues and fresh biomass produced by energy plantations), \$2-4/MBtu. Solar heat costs over a range of \$3-10/MBtu are considered. It is concluded that solar thermal hybrid fuels could be cost competitive with methane produced from coal or biomass alone if the future cost of coal and biomass is near the high end of the projections or if the cost of solar thermal heat can be reduced below current estimates. C.K.D.

A79-38894 * # Solar Stirling system development. J. W. Stearns, Jr., Y. S. Won, P. T. Poon, R. Das, and E. Y. Chow (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1009. 18 p. 15 refs.* Research sponsored by the U.S. Department of Energy.

A low-cost, high-efficiency dish-Stirling solar thermal-electric power system is being developed for test in 1981. System components are the solar concentrator, receiver, fossil fuel combustor, thermal energy storage (TES), engine-generator, and power processing. System conceptualization is completed and design is in progress. Two receiver alternatives are being evaluated, a direct-coupled receiver-engine configuration with no TES and a heat pipe receiver with TES. System cost projections are being made. Goals for the system development task are (1) to develop an advanced dish-Stirling technology, utilizing a team of industrial contractors, (2) to demonstrate that technology at the system level, and (3) to determine how to achieve low production cost. (Author)

A79-38895 # Cost reduction using modular installation for solar heating, cooling and water heating at the life clinic in Brandon, Florida. W. T. Hudson (Independent Living, Inc., Norcross, Ga.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1021. 10 p.*

A solar energy system which is expected to provide 80% of the energy requirements for air conditioning, space heat and domestic hot water in a Florida sports-medical center is described. The system, based on an array of 256 standard size (3 ft by 6.5 ft nominal area) high performance flat collectors with a black chrome finish, provides a total of 1867 times 10 to the 6th Btu per year. The major heat collection loop passes from the collector pump through the collectors, returning to the pump through a series of valves

controlled to bypass the collector loop water to three of the system functions (chiller, hot water storage, swimming pool heat) and a domestic hot water heat exchanger. The combined energy uses offer a potential payback of 12 years. C.K.D.

A79-38896 # Commercialization aspects of solar process hot water systems for the textile industry. J. B. Trice and A. D. Cohen (General Electric Co., King of Prussia, Pa.). *American Institute of Aeronautics and Astronautics, Terrestrial Energy Systems Conference, Orlando, Fla., June 4-6, 1979, Paper 79-1027. 13 p.* Contract No. EY-76-C-03-1220.

This paper describes a solar hot water process heat application for a textile plant located in LaFrance, South Carolina. The system was put into operation in June 1978 and is currently being evaluated. Using cost and performance data from the LaFrance project, an economic analysis has been made to determine the factors required to meet acceptable industry standards for payback periods which are typically 5 years or less in the textile industry. With favorable government tax incentives, solar process hot water systems begin to be competitive with conventional systems in certain parts of the country in the near future. A list of requirements for a program to accelerate development and commercialization of the solar system has been prepared. Suggestions for a proposed program have been outlined, based upon the requirements. (Author)

A79-38947 # Thermodynamic considerations for the energy conversion process in geothermal power plants. K. Nishikawa, S. Yoshida (Kyushu University, Fukuoka, Japan), and H. Mori. *Kyushu University, Faculty of Engineering, Memoirs*, vol. 38, Dec. 1978, p. 327-349. 8 refs.

The utilization factor of energy in a geothermal power plant is considered. For a geothermal power plant, the thermal efficiency does not act as an immediate criterion of economics, because the energy input to this plant is a geothermal fluid free of cost. It is proposed to adopt effectiveness as the utilization factor. Effectiveness is based on the concept of availability, applicable to quantitative assessment of energy according to the second law of thermodynamics. Information derived from some examples of energy and availability accounting for existing geothermal power plants with flashing system is discussed. Based on the effectiveness of geothermal power plants, the optimum flashing pressure is analytically examined. S.D.

A79-38948 # Evaluation of the geothermal potential of Kirishima by resistivity sounding curves. G. Buttacavoli (Palermo, Università, Palermo, Italy) and S. Onodera (Kyushu University, Fukuoka, Japan). *Kyushu University, Faculty of Engineering, Memoirs*, vol. 39, Mar. 1979, p. 1-7. 8 refs.

In order to evaluate the geothermal potential of Kirishima, 230 RS curves were analyzed. Onodera's method, which permits the evaluation of the geothermal potential of an area by the study of RS curves and by comparison with a well known geothermal field of similar geological and geoelectrical structure, was applied to 48 of the curves, which are of the type generally found at a geothermal field of volcanic type and are delimiting two areas of 2.54 and 11 sq km, respectively. Twenty curves out of 48 were found to satisfy the geothermal requirement and the possible power generating capacity of the two areas has been evaluated in 487,000 kW plus or minus 30 percent allowance, or approximately 131,000 kW/k sq km. (Author)

A79-38949 # Environmental implications of energy recovery from municipal solid waste. C. E. Mulkey, G. J. Hyfantis, Jr., and H. G. Moore, Jr. (Tennessee Valley Authority, Div. of Environmental Planning, Chattanooga, Tenn.). *ASME, IEEE, and ASCE, Joint Power Generation Conference, Dallas, Tex., Sept. 10-14, 1978, Paper. 28 p. 30 refs.*

Five techniques of energy recovery from municipal solid wastes are evaluated for their overall environmental compatibility. Direct solid waste combustion with the production of steam has been shown to be compatible with particulate emissions standards if proper air pollution control equipment is employed; however

significant emissions of toxic pollutants have been detected. The use of refuse-derived fuels to supplement fossil fuels in power plants has been found to decrease the efficiency of electrostatic precipitators and increase emissions of eight potentially hazardous trace elements, bottom ash and water effluents. Pyrolysis of organic matter into fuel gas by the PUROX process has been found to lead to acceptable emissions, however in other processes (LANGARD, Torrax) SO_x and particulate emissions have exceeded standards. Biological gasification, while having the potential to produce an environmentally acceptable fuel, exhibits a low energy recovery efficiency. Fluidized bed combustion, which controls emissions during, rather than after combustion, has been demonstrated to be an environmentally safe incineration method, however problems in gas cleaning make it presently unfeasible for energy recovery. A.L.W.

A79-38950 * # Brayton engines for dispersed solar power. T. L. Ashe and L. D. Six (AiResearch Manufacturing Company of Arizona, Phoenix, Ariz.). *American Society of Mechanical Engineers, Gas Turbine Conference and Exhibit and Solar Energy Conference, San Diego, Calif., Mar. 12-15, 1979, Paper. 21 p.* Contracts No. DEN3-69; No. EX-76-A-29-1060.

This paper describes the procedures being used to characterize and to analyze Brayton cycle gas turbines for application in dispersed solar electrical power plants whose cost of electricity is economically viable. Three Brayton engine types are under consideration atmospheric (an open cycle engine), subatmospheric (also an open cycle engine) and the closed cycle engine. This analysis will be utilized to identify and select suitable candidates from existing engine configurations for near-term system demonstrations and to define optimum configurations for production in the 1990 era. Engine designs are being targeted to a system specific capital cost goal of 1000 dollars per design kilowatt, a value believed to make the cost of solar generated electricity competitive. (Author)

A79-39101 * Analysis, development and testing of a fixed tilt solar collector employing reversible Vee-Trough reflectors and vacuum tube receivers. M. K. Selcuk (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *Solar Energy*, vol. 22, no. 5, 1979, p. 413-426. 24 refs. Contracts No. E(49-26)-1024; No. NAS7-100.

The Vee-Trough/Vacuum Tube Collector (VTVTC) aimed to improve the efficiency and reduce the cost of collectors assembled from evacuated tube receivers. The VTVTC was analyzed rigorously and a mathematical model was developed to calculate the optical performance of the vee-trough concentrator and the thermal performance of the evacuated tube receiver. A test bed was constructed to verify the mathematical analyses and compare reflectors made out of glass, Alzak and aluminized GEB Teflon. Tests were run at temperatures ranging from 95 to 180 C during the months of April, May, June, July and August 1977. Vee-trough collector efficiencies of 35-40 per cent were observed at an operating temperature of about 175 C. Test results compared well with the calculated values. Test data covering a complete day are presented for selected dates throughout the test season. Predicted daily useful heat collection and efficiency values are presented for a year's duration at operation temperatures ranging from 65 to 230 C. Estimated collector costs and resulting thermal energy costs are presented. Analytical and experimental results are discussed along with an economic evaluation. (Author)

A79-39102 Parametric cost analysis of photovoltaic systems. V. Evtuhov (Hughes Research Laboratories, Malibu, Calif.). *Solar Energy*, vol. 22, no. 5, 1979, p. 427-433. 10 refs.

A parametric cost analysis of photovoltaic systems based on different design philosophies has been carried out. The analysis takes into account the fixed costs involved in a photovoltaic installation (such as site preparation, array foundations and structure, inversion equipment, backup capacity, etc.) the cost of concentrators at different concentration ratios ranging from unity (i.e. flat plate array) to 1000, solar cell cost-per-unit area, system efficiency, etc.

Resulting parametric curves allow the determination of the cost of electricity for a given set of system constraints. They also allow one to determine the optimum concentration ratio for a given solar cell cost per unit area. The analysis confirms many of the accepted conclusions, presents them in a concise form, and, in addition, allows one to see the relationship between the various system design regimes and the sensitivity of the total cost of electricity produced to the cost of the various system components. (Author)

A79-39103 Thermal energy conversion with fluorescent collector-concentrators. A. Goetzberger (Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung, Institut für angewandte Festkörperphysik, Freiburg im Breisgau, West Germany). *Solar Energy*, vol. 22, no. 5, 1979, p. 435-438. 6 refs.

The potential of fluorescent collectors for thermal conversion is evaluated theoretically. This type of collector has not yet been realized but its possible advantages merit attention. For thermal conversion heat losses are only of importance at the cooling pipe which can be well insulated. Equations are derived describing heat losses for various configurations and operating temperatures. Then conversion efficiencies are calculated. Results are: Fluorescent collectors, although having a lower initial efficiency than flat plate collectors retain this efficiency at high operating temperatures and at low solar flux intensity. (Author)

A79-39104 Performance analysis of dc-motor-photovoltaic converter system. I - Separately excited motor. J. Appelbaum and J. Bany (Tel Aviv University, Tel Aviv, Israel). *Solar Energy*, vol. 22, no. 5, 1979, p. 439-445. 5 refs.

The performance of a solar-electrical system composed of a solar cell array dc separately excited motor and a mechanical load was analyzed. The system operating points in the mechanical plane, (n, T) were transferred to the photovoltaic converter plane (I, U). The relative position of the load line to the maximum power output line of the photovoltaic converter indicates its utilization. The ventilator type load (centrifugal pump) fits very well the converter in contrast to a constant load. The speed variation of the ventilator type load-motor link remains in reasonable limits during the day. For a centrifugal pump, this characteristic corresponds to an almost constant pumping rate during most of the day. (Author)

A79-39105 Commercialisation of solar energy devices in developing countries - Problems and prospects. R. O. Onyeonwu (Benin, University, Benin City, Nigeria). *Solar Energy*, vol. 22, no. 5, 1979, p. 447-449.

The types of solar energy devices that may be economically marketed in developing countries are indicated with particular reference to Nigeria. It is found that the use of solar energy to raise steam in hospitals must remain unattractive for years to come. Qualitative economic assessment indicates that solar agricultural dryers offer great attraction for commercialization. Cost comparison shows that even at the current price of solar cells, water pumping using solar energy is quite attractive. B.J.

A79-39106 Comparison of 100 per cent solar heated residences using active solar collection systems. R. W. Besant and R. S. Dumont (Saskatchewan, University, Saskatoon, Canada). *Solar Energy*, vol. 22, no. 5, 1979, p. 451-453. 11 refs.

Four residences designed using active solar collection systems to provide 100% space heating in cold climates are compared: (1) MIT Solar I; (2) Zero-Energy House in Lyngby, Denmark; (3) Provident House in Toronto; and (4) Saskatchewan Conservation House. It is concluded that the following features should be incorporated in order to achieve 100% solar space heating in a relatively harsh climate with relatively small collector areas and small storage volumes: high standards of energy conservation; well-installed vapor barrier and an air-to-air heat exchanger; insulation levels that substantially exceed current (1978) building standards; thermal shutter systems for windows; use of passive gain through orientation of windows to the equator; and use of high-efficiency solar collectors. B.J.

A79-39508 Diagnostic techniques in combustion MHD flows. S. A. Self (Stanford University, Stanford, Calif.). In: Dynamic measurements in unsteady flows; Proceedings of the Dynamic Flow Conference, Marseille, France, September 11-14, 1978 and Baltimore, Md., September 18-21, 1978. Skovlunde, Denmark, Proceedings of the Dynamic Flow Conference 1978, 1979, p. 685-704. 17 refs. NSF Grant No. ENG-76-04116-A01; Contract No. EX-76-C-01-2341. Project SQUID.

The paper deals with an MHD facility designed for flexibility in research into the basic physics of MHD phenomena. The system employs a liquid fuel spray combustor stabilized by counter swirling injection of oxygen and nitrogen. The adaptation of the system to study the thermal efficiency of a combined MHD/steam plant is described. The particular diagnostic measurement needs for understanding and monitoring the performance of combustion MHD generator systems are outlined. V.P.

A79-39561 Finite beta trapped electron fluid mode. H. R. Strauss (Texas, University, Austin, Tex.). *Physics of Fluids*, vol. 22, June 1979, p. 1079-1081. 7 refs.

The presence of electrons can provide a strong coupling of drift and Alfvén oscillations in toroidal plasmas. Coppi and Rewoldt (1974) have shown that at finite plasma beta, owing to the presence of trapped electrons, there can exist electrostatic ballooning modes, which they call 'ubiquitous' modes. In the present paper, that at longer wavelengths, the ubiquitous modes are destabilized as beta increases. V.P.

A79-39566 Stimulated scattering of light by ion modes in a homogeneous plasma - Space-time evolution. B. I. Cohen and C. E. Max (California, University, Livermore, Calif.). *Physics of Fluids*, vol. 22, June 1979, p. 1115-1132. 37 refs. Research supported by the University of California and Princeton University; Contracts No. W-7405-eng-48; No. E(11-1)-3073.

Stimulated Brillouin scattering, filamentation, and induced Thomson scattering are studied for a coherent electromagnetic plane wave propagating in a uniform plasma. A generalized Green's function is found that describes the impulse response for stimulated scattering by electron and ion modes. Explicit asymptotic Green's functions are calculated for those parametric instabilities involving ion modes or quasi-modes. Special attention is given to whether the instabilities are convective or absolute. For a traveling wave pump in a uniform plasma, Brillouin and induced Thomson backscatter can be absolute, but sidescatter is convective; filamentation of traveling waves is always convective. Spatial growth rates are calculated for convectively unstable modes. Finally, the competition of filamentation and stimulated Brillouin scattering is considered for parameters typical of real laser-fusion experiments. (Author)

A79-39568 Warm plasma effects on drift cyclotron loss cone mode. P. H. Ng, N. T. Gladd, and C. S. Liu (Maryland, University, College Park, Md.). *Physics of Fluids*, vol. 22, June 1979, p. 1141-1147. 18 refs. Research supported by the U.S. Department of Energy.

Although plasma density gradients in mirror machines are larger than the theoretical threshold for the drift cyclotron loss cone instability, turbulence is experimentally observed only at low harmonics of the ion cyclotron frequency. The evolution of the drift cyclotron loss cone instability as the loss cone velocity distribution is progressively filled with a warm Maxwellian component is studied. The addition of the warm plasma results in both a lowering of the growth rate and a distortion and narrowing of the frequency spectrum. Under conditions typical of an almost filled loss cone, the numerical result shows that the growth rate is largest for the lower ion cyclotron harmonics and is quite consistent with experimental observations. (Author)

A79-39593 Spatial uniformity of quantum efficiency of a silicon photovoltaic detector. A. R. Schaefer and J. Geist (National

Bureau of Standards, Washington, D.C.). *Applied Optics*, vol. 18, June 15, 1979, p. 1933-1936. 11 refs.

In the course of investigating the spatial uniformity of response of a silicon detector, an extensive experiment was conducted to examine the correlation between changes in reflectance, internal and external quantum efficiency as a function of position and wavelength on the detector. The sensitivity of the technique was tested and demonstrated in several ways. The examined detector was found to be suitably uniform for absolute radiometric purposes, and the small changes observed in external quantum efficiency can be easily accounted for by the dead layer model. (Author)

A79-39676 Observed resonance lines of highly ionized titanium, chromium, iron, and nickel in tokamak discharges. E. Hinnov (Princeton University, Princeton, N.J.). *Astrophysical Journal, Part 2 - Letters to the Editor*, vol. 230, June 15, 1979, p. L197-L199. 12 refs. Contract No. EY-76-C-02-3073.

Wavelengths and relative intensities were measured in the PLT tokamak discharges for the Ti, Cr, Fe, and Ni ion lithium sequence (2s-2p) and beryllium sequence (2s 2-2s2p 1 P) transitions and some resonance and intercombination lines of Fe XXII and Fe XXIII lines. The discussion is interdisciplinary, covering processes occurring in solar flares as well as tokamak plasmas. B.J.

A79-39695 Double-layer selective coating, high-temperature resistant, for the conversion of solar energy into heat. C. Bellecci, A. Bonanno, M. Conti, L. La Rotonda, and R. Visentin (Calabria, Università, Cosenza, Italy). *Nuovo Cimento C, Serie 1*, vol. 1C, Nov.-Dec. 1978, p. 488-496. 5 refs.

Selective absorption coatings with an absorptivity-to-emissivity ratio of about three have been developed. The selective absorption coatings are based on thin semiconductor films of SnO₂ deposited on ceramic substrates. The coatings are highly conductive, stable for temperatures up to about 300 C, transparent in the visible wavelength and reflective in the infrared region. Solution of the energy conservation equation gives an index of the performance of the surfaces for various working temperatures. J.M.B.

A79-39724 Measurement of the neutron spectra from beam-heated PLT plasmas. J. D. Strachan, G. Schilling, P. Colestock, L. Stewart, H. Eubank, W. Stodiek, L. Grisham, R. Stooksberry, J. Hovey, and K. M. Young (Princeton University, Princeton, N.J.). *Nature*, vol. 279, June 14, 1979, p. 626-628. 11 refs. Contract No. EY-76-C-02-3073.

Neutron spectra from the neutral-beam-heated PLT plasma were measured in order to obtain information on the center-of-mass velocity of the reacting deuteron pairs in the direction parallel to the neutral beam injection. Neutron spectra were recorded by a He-3 ionization chamber during discharges run with hydrogen or deuterium neutral beam co-only and counter-only injection into a deuterium plasma. The spectra from the injection of neutral deuterium show an energy shift of 0.26 MeV between co-only and counter-only injection, which is explained by beam-induced (non-thermonuclear) reactions. Hydrogen neutral beam injection spectra reveal no significant energy shift between co-only and counter-only injection, indicating that neutrons were most likely produced by thermonuclear reactions. It is concluded that no measurable center-of-mass velocity of the reacting deuteron pairs was induced by hydrogen beam injection. A.L.W.

A79-39788 # Materials problems experienced at the Synthane coal-gasification pilot plant. S. Danyluk, G. M. Dragel (Argonne National Laboratory, Argonne, Ill.), and D. Dubis (U.S. Department of Energy Synthane Coal Gasification Pilot Plant, Pittsburgh, Pa.). *ASME, Transactions, Journal of Engineering Materials and Technology*, vol. 101, Apr. 1979, p. 105-113. 9 refs. Research supported by the U.S. Department of Energy.

Some failure experiences with metallic components at the Synthene coal-gasification pilot plant are presented. In some cases, corrosion caused by a sulfur environment was a major factor in the failure initiation. Several instances of improper component manufacture or heat treatment led to failures. Chloride-assisted stress-corrosion cracking and an improper materials choice contributed to two cases of failure. In most cases, the recommended changes in materials, design or process conditions have resulted in an increase in component life. (Author)

A79-39806 * # NASCAP modelling of high-voltage power system interactions with space charged-particle environments. N. J. Stevens, J. C. Roche (NASA, Lewis Research Center, Cleveland, Ohio), and M. J. Mandell (System, Science and Software, La Jolla, Calif.). *Institute of Electrical and Electronics Engineers, High Voltage Workshop, Anaheim, Calif., Feb. 26, 27, 1979, Paper. 18 p.* 22 refs.

The NASA Charging Analyzer Program (NASCAP), an engineering tool capable of analyzing the impact of the charged particle environment on spacecraft surfaces and systems, is described. NASCAP is a quasi-static computational program which analyzes the charging of a 3-dimensional complex body as a function of time and system-generated voltages for given space environmental conditions. The material properties of the surfaces are taken into account; the surface potentials, low energy sheath, potential distribution in space and particle trajectories are calculated. An application of NASCAP to a simple space solar power station consisting of two 6 m by 18 m solar array wings surrounding a central body is presented. Each solar array wing is considered to be divided into three regions operating at 2000 volts. Results of NASCAP analysis of the system for a normal environment and a moderate geomagnetic substorm environment are discussed. C.K.D.

A79-39807 * # Preliminary results in the NASA Lewis H2-O2 combustion MHD experiment. J. M. Smith (NASA, Lewis Research Center, Cleveland, Ohio), Montana Energy and MHD Research and Development Institute, Montana College of Mineral Science and Technology, and Montana State University, *Symposium on the Engineering Aspects of Magnetohydrodynamics, 18th, Butte, Mont., June 18-20, 1979, Paper. 9 p.*

MHD power generation experiments have been carried out in the NASA Lewis Research Center cesium-seeded H2-O2 combustion facility. This facility uses a neon-cooled cryomagnet capable of producing magnetic fields in excess of 5 tesla. The effects of power takeoff location, generator loading, B-field strength, and electrode breakdown on generator performance are discussed. The experimental data is compared to a theory based on one-dimensional flow with heat transfer, friction, and voltage drops. (Author)

A79-39839 Effect of diffusion on electron density across the nonequilibrium MHD channel. M. S. Sodha, B. K. Gupta, and R. P. Sharma (Indian Institute of Technology, New Delhi, India). *Energy Conversion*, vol. 19, no. 1, 1979, p. 1-8. 13 refs. NSF-supported research.

This paper presents an investigation of the effect of thermal diffusion of charge carriers on the electron density in a nonequilibrium MHD generator. The source of diffusion is the inhomogeneity in the background temperature and/or the nonuniform heating of electrons across the MHD channel cross section on account of the velocity boundary layer. The continuity equation of electrons has been solved in conjunction with the diffusion velocity equation to obtain the steady state electron density distribution in an MHD generator. As a result of diffusion, the electron density is found to increase with the distance from the channel axis, while the reverse is predicted from the assumption of local equilibrium. Further, it is seen that the increase in the values of Hall parameter, boundary layer thickness and the flow velocity enhances the effect of diffusion. Decrease in the wall temperature is also found to have a similar effect. The diffusion of the carriers is most prominent in the

segmented geometry. It is concluded that overall electron density gets enhanced if recombination and diffusion times are of the same order. (Author)

A79-39840 An incremental model for conversion of solar energy in agricultural systems. M. Sanai (Arya Mehr University of Technology, Teheran, Iran). *Energy Conversion*, vol. 19, no. 1, 1979, p. 9-13. 10 refs.

An incremental model is devised in which various sectors present in a soil-water-plant system are viewed as a series of discrete 'compartments' between which material and energy flow. Each compartment is to represent one of the main parameters encountered and the relations of compartments are assumed to be characterized by constant-coefficient linear differential equations. Various coefficients that appear in the governing equations of a computerized version of this model are determined for alfalfa cultivation. Results indicate the balance and interrelation of all the elements involved and lead to the prediction of biomass energy yield per unit farm area, efficiency of photosynthetic conversion, and the cycling of the main nutrients. B.J.

A79-39841 Electric effects in window-frame MHD generators with non-uniform velocity and conductivity in the transverse plane. S. E. Shamma (MIT, Cambridge, Mass.; West Florida, University, Pensacola, Fla.), M. Martinez-Sanchez, and J. F. Louis (MIT, Cambridge, Mass.). *Energy Conversion*, vol. 19, no. 1, 1979, p. 15-24. 5 refs. NSF Grant No. MCS-76-18953; Contract No. E(49-18)-2215.

This paper presents analytical results for the dependence of the electric field and current, as well as the integral characteristics of Window-Frame MHD generators, on the inhomogeneity of velocity and conductivity in the transverse plane. Exact solutions of the electric potential and integral parameters are presented for the case of cylindrical channels with elliptic cross sections, and detailed cases are given graphically for a range of frame angles, channel aspect ratios and type and strength of boundary layers. (Author)

A79-39842 Performance matching and optimization of wind powered water pumping systems. G. M. Bragg and W. L. Schmidt (Waterloo, University, Waterloo, Ontario, Canada). *Energy Conversion*, vol. 19, no. 1, 1979, p. 33-39. 7 refs. Research supported by the International Development Research Centre.

A79-39843 Performance of a collector/storage solar water heater. M. S. Sodha, J. K. Nayak, S. C. Kaushik, S. P. Sabberwal (Indian Institute of Technology, New Delhi, India), and M. A. S. Malik (Kuwait Institute for Scientific Research, Kuwait, Kuwait). *Energy Conversion*, vol. 19, no. 1, 1979, p. 41-47. 7 refs.

This communication presents an improved analysis of a collector/storage solar water heater proposed by Garg (1975). The heater consists essentially of an insulated rectangular tank whose top surface is suitably blackened and glazed. After collection of solar energy during day the heater can store a substantial amount of heat for an appreciable time if the top glass is covered by adequate insulation (assumed to be of the same thickness as the insulation below the tank) during the night. Expressions for the transient temperature of the water in the tank have been derived. The hourly variation of temperature of the water in the tank was determined. These experimental results have been found to be in close agreement with the theory presented in this paper. (Author)

A79-39844 A novel thermal engine using metal hydride. K. Nomura, Y. Ishido, and S. Ono (National Chemical Laboratory for Industry, Tokyo, Japan). *Energy Conversion*, vol. 19, no. 1, 1979, p. 49-57. 10 refs.

A unique and compact prototype piston engine using LaNi5Hx as an energy conversion medium was developed. It consists of two

metal hydride containers, each having about 700g (1.6 moles) of LaNi_5H_x powder, a cylinder and piston and two electromagnetic valves which work and synchronize with the movement of the piston. When one of the containers was heated in a hot water bath (80 C) and the other was cooled down to 20 C the piston was kept working by the hydrogen pressure difference of about 10kg/sq cm between them. On the average, 28 W of mechanical power output was generated for two minutes. The theoretical conversion efficiency is 15.5% and the roughly estimated experimental value is 7.7%.

(Author)

A79-39845 Simulation studies of the basic non-linear effects of wave-energy conversion by an overtopping water-column. G. F. Knott and J. O. Flower (Sussex, University, Brighton, England). *Energy Conversion*, vol. 19, no. 1, 1979, p. 59-69. Research supported by the Science Research Council.

Several forms of wave-energy devices are currently being developed which incorporate oscillating ducted-flows. A method of extracting energy from such flows has been suggested whereby fluid is allowed to spill over from the top end of the duct during some portion of the oscillatory cycle into an elevated reservoir from whence it is directed through a low-head turbine. A mathematical model of this energy conversion system has been derived for simulation in a digital computer; and the results of the analysis are presented here in terms of the efficiency of operation relative to the optimum linear case. The simulation is repeated for a wide range of input conditions and operating parameters. The conclusions drawn from this work may be seen to have a wider application in the field of non-linear energy exchange in resonant mechanical systems.

(Author)

A79-39850 Determination and interpretation of the geothermal flux at Bournac /Haute-Loire/ (Détermination et interprétation du flux géothermique à Bournac /Haute-Loire/). M. Daignieres and G. Vasseur (Montpellier II, Université, Montpellier, France). *Annales de Géophysique*, vol. 35, Jan.-Mar. 1979, p. 31-39. 23 refs. In French. Research supported by the Institut National d'Astronomie et de Géophysique.

A method for the determination of heat flow in a nonstratified medium is presented. It is applied to data obtained at Bournac (Haute-Loire), leading to a value of 86 mW/sq m. Using previous studies about the composition and structure of the crust at this place a deep geotherm is proposed and its various implications are discussed.

(Author)

A79-39909 Post mortem assessment - Coal gasification plant. S. S. Canja (U.S. Department of Energy, Washington, D.C.) and F. H. O'Donnell (TRW Energy Systems Group, McLean, Va.). In: Annual Reliability and Maintainability Symposium, Washington, D.C., January 23-25, 1979, Proceedings. New York, Institute of Electrical and Electronics Engineers, 1979, p. 291-300. 13 refs.

This paper describes recent work of the Department of Energy in collecting, documenting and analyzing materials and components performance data from a high Btu coal gasification plant - the Carbon Dioxide Acceptor Pilot Plant, at the end of its operational demonstration phase and just before plant shut-down. The purpose of the assessment was to review plant operational records to extract failure, maintenance and operability data and information which would be useful in the design, construction and operation of future coal gasification plants. The main sources of data were run reports, shut-down reports, inspection reports and monthly progress reports. These records were largely narrative in nature and required extensive analysis to extract the desired information.

(Author)

A79-39938 Fuel preconditioning studies for e-beam fusion targets. J. N. Olsen, M. M. Widner, J. Chang, and L. Baker (Sandia

Laboratories, Albuquerque, N. Mex.). *Journal of Applied Physics*, vol. 50, May 1979, p. 3224-3230. 14 refs. Contract No. AT(29-1)-789.

Fuel temperature and density conditions, achieved during the preheat phase of electron-beam fusion compression experiments, must be accurately known to understand experimental results via numerical simulations. The paper presents studies of discharge preheating in a simplified cylindrical geometry which compare measured quantities with results from the one-dimensional Lagrangian CHARTB magnetohydrodynamic code. Experimental measurements included schlieren photography and ultraviolet through visible time- and space-resolved spectroscopy in various configurations. It is seen that an 8-kA 500-ns heating pulse in 100 torr of $\text{D}_2 + 10\% \text{O}_2$ produces 10-12 eV temperatures, 10 to the 18th/cm electron densities, and 700,000 cm/s expansion velocities in the heated discharge channel. These results are consistent with previous claims for neutron-producing targets, although the target geometry is different.

(Author)

A79-39940 Temporally and spatially resolved harmonic emission from spherical laser fusion targets. T. A. Leonard (KMS Fusion, Inc., Ann Arbor, Mich.; Dayton, University, Dayton, Ohio) and R. A. Cover (KMS Fusion, Inc., Ann Arbor, Mich.). *Journal of Applied Physics*, vol. 50, May 1979, p. 3241-3246. 16 refs. Contract No. ES-77-C-02-4149.

An electro-optic streak camera was used to record 2(ω sub 0) and 3/2(ω sub 0) harmonic emission from glass microsphere targets irradiated with a 0.3-TW Nd:glass laser. These two harmonic frequencies are produced at the critical and quarter-critical surfaces, respectively, and thus provide a measure of these electron-density trajectories. After applying a refraction correction to the data, the trajectories were compared with predictions from the KMSF TRHYD code. It was found that hydrodynamic development in the critical-density region was accurately depicted by the temporal behavior of the 2(ω sub 0) emission. In addition, observed periodic fluctuations in 3/2(ω sub 0) emission along a meridian give direct evidence of density rippling in the underdense corona.

(Author)

A79-39944 Solar-cell characteristics and interfacial chemistry of indium-tin-oxide/indium phosphide and indium-tin-oxide/gallium arsenide. K. J. Bachmann, H. Schreiber, Jr., W. R. Sinclair, P. H. Schmidt, F. A. Thiel, E. G. Spencer, G. Pasteur, W. L. Feldmann, and K. SreeHarsha (Bell Telephone Laboratories, Inc., Murray Hill, N.J.). *Journal of Applied Physics*, vol. 50, May 1979, p. 3441-3446. 12 refs.

A79-39945 Theoretical efficiency of SnO_2/Si solar cells. A. K. Ghosh, C. Fishman, and T. Feng (Exxon Research and Engineering Co., Linden, N.J.). *Journal of Applied Physics*, vol. 50, May 1979, p. 3454-3458. 16 refs. Contract No. E(04-3)-1283.

At present SnO_2/Si solar cells with efficiencies greater than 12% have been fabricated. The maximum theoretical efficiency attainable with such cells is of great interest and is reported in the present paper. The cells behave very much like MIS devices. The insulating oxide and surface density of states at the interface affect the performance of the device mainly through the diode constant and the barrier height. The theoretical maximum short-circuit photocurrent, the open-circuit photovoltage, and the fill factor are 36 mA/sq cm, 0.66 V, and 0.84, respectively. They yield a maximum theoretical efficiency of 20%.

(Author)

A79-39993 Capital investment for transition to new energy supply systems (Der Kapitaleinsatz beim Übergang zu neuen Energieversorgungssystemen). D. J. Volkmann. *Energiewirtschaftliche Tagesfragen*, vol. 29, May 1979, p. 231-234, 236. In German.

The substitution of exhaustible fossil fuels with other production factors, especially technology and capital, and the resulting tasks for the economics and politics of the consumer countries, are

discussed. International Institute for Applied Systems Analysis energy consumption estimates assume 16.5 kW of consumption for each person in North America in 2030. Three long term options are presented: (1) Atomic power with breeder reactors, (2) Solar energy requiring use of millions of sq km of land, (3) Fossil fuels using expensive and poorly accessible, non-conventional resources that are not under consideration today. Demands on capital investment according to IIASA estimates are covered as is the method by which they were derived. It is concluded that this estimation method yields more definitive data than do trend extrapolation and economic analyses. M.E.P.

A79-39994 Critical comments on energy models (Kritische Anmerkungen zu Energiemodellen). H. Trenkler. (*Arbeitsseminar über Energiemodelle für die Bundesrepublik Deutschland, 2nd, Jülich, West Germany, Mar. 2, 1979.*) *Energiewirtschaftliche Tagesfragen*, vol. 29, May 1979, p. 246-250. In German.

The problems of predicting future energy consumption are studied and the use of system technology to construct energy models is analyzed. Attention is given to energy prognoses and the problem of predicting growth in demand, which must deal with factors such as decreased growth rates, price changes in various energy sources, substantial cost changes and longer construction times for power plants, structural changes in the economy, and stagnation of population development. The use of energy models as a planning basis for the expansion of power plants is considered. The various areas covered in which government affects energy planning include: environmental issues, research, subsidization, and securing the energy supply against political upheavals. M.E.P.

A79-40008 A thermoanalytical investigation of nickel catalysts for fuel cells (Thermoanalytische Untersuchung von Nickelkatalysatoren für Brennstoffzellen). H. Grüne (Siemens AG, Forschungslaboratorien, Erlangen, West Germany). *Siemens Forschungs- und Entwicklungsberichte*, vol. 8, no. 3, 1979, p. 168-174. 16 refs. In German. Research supported by the Bundesministerium für Forschung und Technologie.

It is shown that undesirable oxidation reactions can be used in the quantitative evaluation of the catalyst for practical applications. Attention is given to the behavior of Raney catalysts in fuel cells and a more suitable measuring technique which offers a better insight into these processes. The reduction processes and oxidation reaction are investigated. Applications are presented and include an example emphasizing the suitability of the technique for samples of small specific surface. This involved determining that the area of nickel powder, resulting from the reduction of nickel oxalate, was 3.1 sq m/g. This would mean a diameter of 0.22 microns, assuming a spherical form, which agrees with results obtained in another manner. M.E.P.

A79-40024 Aluminum in solar technology (Aluminium in der Solartechnik). G. Dick (VAW Leichtmetall GmbH, Bonn, West Germany). *Metall*, vol. 33, June 1979, p. 681-684. In German.

The use of aluminum and its alloys, i.e., AlMn, AlMg3, AlMgSi(0.5), and AlMgSi(1), in the construction of flat-plate and concentrating collectors is discussed. Particular consideration is given to (1) the use of aluminum in the construction of large-surface absorbers for the indirect utilization of solar energy, and (2) corrosion problems associated with heat-carrying fluids for aluminum collectors and absorbers. B.J.

A79-40068 H₂S emissions in the domain of chemical industry and means of suppressing emissions (H₂S-Emissionen auf dem Gebiet der chemischen Industrie und Möglichkeiten der Emissionsminderung). H. J. Frost. *Staub - Reinhaltung der Luft*, vol. 39, May 1979, p. 186-189. In German.

In the present paper, various chemical processes which give rise to H₂S emission are reviewed, along with the respective chemical

reactions. Means of suppressing H₂S emissions of industrial origin are discussed, with particular reference to wet desulfurization and dry purification. V.P.

A79-40069 H₂S associated with mineral oil refineries and natural gas processing plants - Emissions and absorptions (H₂S bei Mineralölraffinerien und Erdgasaufbereitungsanlagen - Emissionen und Immissionen). K. Gasiorowski. *Staub - Reinhaltung der Luft*, vol. 39, May 1979, p. 189-191. 6 refs. In German.

The measurements discussed in the present paper were carried out at a number of refineries, always within a square, 8 by 8 km, area about the refinery stack. In each case, measurements were made at 16 points spaced 2 km apart. H₂S measurements were made with a gaschromatograph with a flame photometry attachment. From the 80 summertime and 96 wintertime data sets obtained it could be seen that the summer mean value of 5.3 micrograms per cubic meter was twice the winter mean value (2.3 mg/cu m). This is attributed to the higher summertime activity of biological H₂S sources. V.P.

A79-40073 Review of hydrodynamics and heat transfer for large helium cooling systems. M. C. Jones and V. D. Arp (National Bureau of Standards, Cryogenics Div., Boulder, Colo.). (*Conference on Advances in Refrigeration at the Lowest Temperatures, Zurich, Switzerland, Mar. 1-3, 1978.*) *Cryogenics*, vol. 8, Aug. 1978, p. 483-488; Discussion, p. 488-490. 69 refs.

This paper is a review of recent experimental results and computational methods needed for the fluid engineering aspects of helium cooling systems for power applications. The discussion is illustrated by three different applications: large magnets; power transmission lines and ac generators. An attempt is made to put recent research into perspective, considering the requirements of each application, and problems in need of further research are pointed out. (Author)

A79-40101 International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Symposium sponsored by the British Hydromechanics Research Association. Edited by H. S. Stephens (British Hydromechanics Research Association, Cranfield, Beds., England). Cranfield, Beds., England, British Hydromechanics Research Association, 1978. 447 p. \$45.26.

National wind energy programs in the Netherlands, Sweden, the USA, Japan, and Tanzania, and wind characteristics programs are presented. Consideration is given to the aeroelastic stability and behavior of wind rotors, theoretical and experimental data, and new concepts, such as a variable geometry vertical axis windmill and a flexible blade windmill. Attention is paid to such systems aspects as an economic model to establish the value of the Wind Energy Conversion Systems (WECS) to a utility system, and the regulation of an electricity supply system including wind energy generators. V.T.

A79-40102 The Netherlands research program on wind energy. G. G. Piepers and P. F. Sens (Netherlands Energy Research Foundation - ECN, The Hague, Netherlands). In: *International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1.* Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. A1-1 to A1-6.

The first phase of the program includes orientation, collection, and evaluation of existing information while proposals for research and development are specified in more detail for the second phase that runs from 1977 to 1979. An experimental Darrieus windturbine with a 5 meter diameter has been designed and constructed for investigation purposes. In the second phase various systems including electrical, electronic, and mechanical components for the conversion of mechanical energy to electricity are studied. A new development that has been included in the program is the study of the effects of tip-vanes on the efficiency of horizontal axis turbines. Possibilities

for location of large numbers of windmills are discussed and a list of institutes and industries involved in the execution of the national research program on wind energy is given. During the third phase the design, fabrication, assembly, and testing of a vertical axis windturbine of the same rotor diameter and rated energy output as the horizontal axis windturbine will be undertaken. V.T.

A79-40103 The Swedish Wind Energy Programme. S. Hugosson (National Swedish Board for Energy Source Development, Sweden). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. A2-7 to A2-15.

The second, multifaceted stage of the National Swedish Board for Energy Development wind energy program, now in process, is divided into the following subprograms: (1) future systems; (2) system integration; (3) meteorology; (4) environment and safety; (5) local systems; (6) experimental unit; (7) prototypes; (8) prototypes evaluation; and (9) demonstration group. The work is centered around a reliable and simplified unit of 8-10 kW size, equipped with an induction (asynchronous) generator for straightforward connection to a stable grid. Specific consideration is given to the prototype phase: prototype specification, design study and construction, delivery test, and evaluation. The prototypes are planned to enter operation and evaluation in 1981. V.T.

A79-40104 Recent developments in wind energy. L. V. Divone (U.S. Department of Energy, Washington, D.C.). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. A3-17 to A3-28.

The changing trend over the past few years from studies and estimates to actual experiments is described. Testing programs on both small wind turbines for dispersed, private use, systems and large utility class machines are presented. Non-technical issues such as demand charges for the small systems and the potential for TV interference with large systems are addressed. The present understanding of the economics of wind systems, particularly those interconnected with a utility system, shows cost requirements of 1 cent to 2 cents per kilowatt hour in today's economy to achieve a significant market. Present experimental and prototype systems produce energy at 10 cents to 20 cents per kilowatt hour. The potential for research and development and production maturity to reach the cost requirements is discussed. Two techniques, the 'spider diagram' and the use of kilowatt hours per year per pound as a figure of merit are presented. Present values of this parameter are in the range of 10, while the target range for large scale use is between 25 and 40. Developing international cooperation in wind energy, both through the International Energy Agency and bi-national agreements, is discussed. (Author)

A79-40105 The development of wind power plants in Japan. I. Ushiyama (Ashikaga Institute of Technology, Ashikaga, Tochigi, Japan). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. A4-29 to A4-44. 10 refs.

A79-40106 Windpower programmes in Tanzania. R. S. Reichel (Dar es Salaam, University, Dar es Salaam, Tanzania). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. A5-45 to A5-52. 8 refs.

A79-40107 Physical planning aspects of large-scale wind energy exploitation in the Netherlands. A. A. van Essen (Rijks Planologische Dienst, Netherlands), R. ter Brugge, J. M. van den Berg

(Keuring van Elektrotechnische Materialen, Arnhem, Netherlands), G. G. Piepers (Netherlands Energy Research Foundation - ECN, The Hague, Netherlands), and A. L. M. Bongaarts (Ministry of Economic Affairs, Amsterdam, Netherlands). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B1-1 to B1-10.

A79-40108 Program overview for the wind characteristics program element of the United States Federal Wind Energy Program. L. L. Wendell and C. E. Elderkin (Battelle Pacific Northwest Laboratories, Richland, Wash.). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B2-11 to B2-20. 18 refs.

A79-40109 Wind energy prospecting in Prince Edward Island - A program overview and status report. M. Lodge (Institute of Man and Resources, Canada). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B3-21 to B3-32. 6 refs.

A79-40110 Offshore wind power model estimates. M. Garstang, R. Pielke, C. Aspliden, and J. W. Snow (Virginia, University, Charlottesville, Va.). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B4-33 to B4-48. Contract No. EY-76-S-06-2344.

A two- and three-dimensional mesoscale model and the model predicted wind fields on a coastline are described and a preliminary analysis of the frontal-cyclone or synoptic scale influences upon the observed wind fields along the northeast coast of the USA from a wind energy conversion point of view is presented. Almost all two-dimensional model calculations presented show that, at 50 m above the surface, the power density at 5.5 km offshore is more than double that at 5.5 km onshore. The three-dimensional calculations show that nocturnal stratification results in wind speed maxima migrating out over the water. It is noted that the potential power of the coastal wind models in predicting optimum locations of wind energy conversion systems in a region of poor observation is good. Application of modeling methods, however, depend upon convincing verification of model predictions. V.T.

A79-40111 The interaction of windmill wakes. P. J. H. Bultjes (Netherlands Centrale Organisatie TNO, Nijverheidsorganisatie TNO, The Hague, Netherlands). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B5-49 to B5-58. 7 refs.

In a windtunnel the wake of a turning model of a Darrieus-rotor has been measured in a homogeneous flow field. This wake has been simulated on a smaller scale by a stationary grid to be able to investigate a group of windmills. The stationary grid has been placed in the scaled atmospheric boundary layer of the windtunnel and the wake of it within this layer has been measured. In order to simulate the interaction of the wakes of a whole group or park of up to about 100 windmills the grids have been placed on a circular turn-table in the windtunnel. By measuring the force on the different windmill-simulating grids in a group an estimate can be made of the energy output of such a group of windmills. By doing so for different spacings between the windmills an idea can be gained about the size of the spacing that is required to get a maximum energy output of a group of windmills on a given area. The results show that a maximum output is reached of about 7 W/sq m with a spacing of about 6.5 windmill diameters. (Author)

A79-40112 Wake interaction in an array of windmills - Theory and preliminary results. T. Faxen (Uppsala, Universitet, Uppsala, Sweden). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B6-59 to B6-72. 6 refs.

A model developed for predicting power output of a general array of wind turbines is presented. The fluid mechanics of wake development are analyzed and it is shown that, if radius and wake profile are known, the wake velocity can be determined. A procedure to handle the combined effects of ambient and mechanical turbulence is given. Ground effect is simulated by imaging techniques, and multiple turbine interactions by averaging and superposition methods. Exercise of the model indicates that for large arrays significant power losses can occur for improper geometry. The importance of natural turbulence is surveyed. This shows that the bigger the array, the more important it is to get an estimate of this turbulence. Wake profiles obtained in field test at the 60 kW test unit are compared to that predicted by the model and a good correlation is found. V.T.

A79-40113 Measurement of wind speed around a wind power plant in Sweden. A.-S. Smedman-Hogstrom (Uppsala, Universitet, Uppsala, Sweden). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. B7-73 to B7-84. 11 refs. Research sponsored by the Swedish National Board for Energy Source Development.

A79-40114 Atmospheric turbulence structure in relation to wind generator design. N. O. Jensen and S. Frandsen (Riso National Laboratory, Roskilde, Denmark). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. C1-1 to C1-12. 13 refs.

Wind generator design criteria, both for structural strength and generating performance, depend critically upon the structure of the ambient wind. Under conditions appropriate for wind power generation the atmospheric boundary layer will always be in a turbulent state. Hence, generator design must acknowledge the stochastic nature of turbulent wind variations. Many properties of boundary layer turbulence can be usefully parameterized in terms of various spectral distributions including spatial phase and coherence relations. This paper summarizes our empirical knowledge of these concepts. (Author)

A79-40115 Performance evaluation of wind power units. O. Holme (Saab-Scania AB, Linköping, Sweden). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. C2-13 to C2-30.

A method for evaluating the performance of wind power units (WPU) is presented. It is shown that the mean power output can be expressed in terms of the nondimensional parameters relative mean power and mean power coefficient as functions of the ratio between the WPU characteristic wind speed at the WPU site, the reduced tip speed (for turbines with constant tip speed), power loss coefficients, reduced cut-off speed, and a wind speed duration function shape parameter. The method has been applied to turbines with smooth surface conditions, corresponding to normal standards of airplane manufacture, and rough surface conditions, corresponding to lower manufacturing standards or to deterioration in service. The effects of varying the wind speed duration function shape parameter have been studied for a smooth, constant tip speed, variable pitch turbine. The parameter with greatest influence on WPU performance is the ratio between the WPU characteristic wind speed and the mean wind speed at the WPU site. C.K.D.

A79-40116 Investigations on the aeroelastic stability of large wind turbines. H. H. Ottens and R. J. Zwaan (Nationaal Lucht-en Ruimtevaartlaboratorium, Delft, Netherlands). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. C3-31 to C3-48. 7 refs. Research supported by the Netherlands Energy Research Foundation.

The aeroelastic stability of a vertical axis Darrieus wind turbine with a two-blade rotor 5 m in diameter is examined. The blades are fabricated of glass reinforced epoxy, while the shaft and supporting structure are in steel. The stability of the system is analyzed using a method described elsewhere (Ottens and Zwaan, to be published) from equations of motion which are linearized with respect to blade deflections. The wind turbine is analyzed with and without a tie-down system. It is shown that addition of a tie-down system may reduce the critical speed and introduce new aerodynamic instabilities. However, a tie-down system may still be effective in reducing shaft deflections. C.K.D.

A79-40117 * Aeroelastic stability and response of horizontal axis wind turbine blades. S. B. R. Kottapalli, P. P. Friedmann (California, University, Los Angeles, Calif.), and A. Rosen (Technion - Israel Institute of Technology, Haifa, Israel). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. C4-49 to C4-66. 25 refs. Grant No. NSG-3082.

The coupled flap-lag-torsion equations of motion of an isolated horizontal axis wind turbine blade are formulated. Quasi-steady blade-element strip theory was applied to derive the aerodynamic operator which includes boundary layer type gradient winds. The final equations which have periodic coefficients were solved in order to obtain the aeroelastic response and stability of large horizontal axis wind turbine blade. A new method of generating an appropriate time-dependent equilibrium position (required for the stability analysis) has been implemented. Representative steady-state responses and stability boundaries, applicable mainly to an existing blade design (NASA/ERDA MOD-0), are presented. The results indicate that the MOD-0 configuration is a basically stable design and that blade stability is not sensitive to offsets between blade elastic axis and aerodynamic center. Blade stability appears to be sensitive to precone. The tower shadow (or wake) has a considerable effect on the flap response but leaves blade stability unchanged. Finally, it was found that non linear terms in the equations of motion can significantly affect the linearized stability boundaries, however, these terms have a negligible effect on blade response at operating conditions. (Author)

A79-40118 The aeroelastic behaviour of large Darrieus-type wind energy converters derived from the behaviour of a 5.5 m rotor. A. J. Volland (Dornier System GmbH, Friedrichshafen, West Germany). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. C5-67 to C5-88. 8 refs.

The conditions of similarity for Darrieus rotors of different sizes and troposkein shaped blades are investigated on the basis of the aeroelastic behavior of a 5.5 m vertical axis wind energy converter. The test system has 3 or 4 blades of extruded aluminum. The tower is a truss construction supported by 3 guy wires. The aerodynamic behavior of scaled-up rotors is analyzed using a previously described (Volland, 1977) finite element model. The types of instability considered include centrifugal divergence, aerodynamic divergence, mechanical flutter, internal damping-induced instability, classical bending-torsion flutter, vertical axis rotor flutter, and tower buckling instability. It is shown that the rotors are similar with respect to their static and aeroelastic behavior, with the exception of gravity stress. In scaling up the rotor, the design must be optimized to reduce

weight and avoid excessive bending stresses due to gravity load. In lower weight blades, the ratio of air to blade mass increases, indicating that light flutter instabilities become significant in the absence of adequate structural damping. The critical wind speed is found to be proportional to blade solidity and inversely proportional to the equatorial speed ratio and to the square root of the ratio of the Young modulus to density of the material. C.K.D.

A79-40119 Gears for wind power plants. P. Thornblad (Stal-Laval Turbin AB, Finspang, Sweden). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. C6-89 to C6-106.

Factors affecting the size, weight and cost of gears for large wind power plants are examined. The weight, cost and size of several configurations for planetary and parallel gears are compared. It is shown that planetary gears used at the high torque end of the transmission offer distinct advantages over parallel gears. Installation and foundation requirements for wind power plant gearing are examined. An epicyclic gear design which is entirely isolated from static changes of the shafts and foundations is presented. A version featuring a triple reduction planetary gear design is discussed in detail. C.K.D.

A79-40120 Test results from the Swedish 60 kW experimental wind power unit. B. Gustavsson and G. Törnkvist (Saab-Scania AB, Linköping, Sweden). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. D1-1 to D1-8. 9 refs. Research sponsored by the Swedish National Board for Energy Source Development.

The performance of a 60 kW wind turbine is reported. The turbine has two blades with a NACA 64 sub 3-618 airfoil modified to avoid a concave surface. The turbine was equipped with a measuring and recording system to monitor wind speed and direction and strains on the blades, hub and bedplate. In addition, infrasound measurements were made. A fundamental tone occurs at about 2.5 Hz with a sound pressure of about 60 dB. The turbine produced 1720 kWh during 70 hours of operation, corresponding to an average power of 24.5 kW. The response of the blades to wind gusts was computed with a model which considers flapping, lead-lag and torsion and which includes centrifugal and gravitational loads. Linear aerodynamic coefficients were obtained by a method based on the blade element theory of Lock (1945). The computed blade bending moments flapwise were in good agreement with measured values; however, the bending moments in the lead-lag direction and the bedplate were greater than predicted. C.K.D.

A79-40121 Measurements of performance and structural response of the Danish 200kW Gedser windmill. P. Lundsager (Riso National Laboratory, Roskilde, Denmark), V. Askegaard (Danmarks Tekniske Højskole, Lyngby, Denmark), and E. Bjerregaard (Danish Ship Research Institute, Denmark). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. D2-9 to D2-26. 5 refs.

A test program for measuring the performance and structural response of a 200 kW Gedser windmill is described, and preliminary results are presented. The three-bladed, stall-regulated rotor is located upwind. Blades are stiffened by stays. The rotor instrumentation, including 84 channels, 46 of which are telemetered from the rotor, follows a layout determined from preliminary laboratory tests on single blades. Preliminary data indicate that stresses in the structure are low. Observations at low wind speeds indicate that the response of the structure is mostly sinusoidal, suggesting that gravity and wind shear predominate. At higher wind speeds turbulence may have some significance. C.K.D.

A79-40122 Operating experience with the Magdalen Islands wind turbine. P. South, R. S. Rangi, and R. J. Templin (National Research Council, Ottawa, Canada). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E1-1 to E1-10.

A79-40123 A 200kW vertical axis wind turbine - Results of some preliminary tests. J. H. VanSant, R. D. McConnell, and A. Watts (Hydro-Québec, Institut de Recherche, Varennes, Canada). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E2-11 to E2-22. 5 refs.

An experimental vertical axis wind turbine has been installed in the Magdalen Islands by Hydro-Québec. A performance evaluation program is being carried out jointly with the National Research Council who also supplied the turbine. The rotor is 37 meters high by 24 meters diameter at its equator and has two curved symmetrical airfoils. Through a mechanical drive system, it powers a 224kW induction generator which is connected to the island's electrical distribution grid. The generator is used as a starting motor and also to keep the turbine running at near constant speed. The turbine has been operated at approximately three-fourths rated speed by changing its belt-drive pulley. Some results of performance measurements at this speed are presented with other data. Also, a description of the turbine's mechanical and electrical systems are given. (Author)

A79-40124 The design, construction, testing and manufacturing of vertical axis wind turbines. R. H. Braasch (Sandia Laboratories, Albuquerque, N. Mex.). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E3-23 to E3-38. 10 refs. Research supported by the U.S. Department of Energy.

The design, construction and testing of a 17-meter Darrieus type vertical axis wind turbine (VAWT) are described, and results of a performance-cost optimization study and manufacturing studies of VAWTs are presented. Two- and three-blade rotor configurations have been tested. The blades are troposkein-shaped, with a symmetrical airfoil cross section developed from helicopter-blade technology. The power train has 13 gear-ratio settings and both induction and synchronous electrical power generation are possible. Results of tests measuring performance parameters, blade operating stress levels, fatigue life, and machine torque ripple are presented. Estimated energy cost trends versus machine diameter and rated machine output power are reported, together with expected torque, power, and weight, for VAWTs of different sizes. The basic design considered incorporates extruded aluminum blades, large diameter/low weight spiral wrapped and welded steel towers, a two-bladed rotor, a height-to-diameter ratio of 1.5, a stiff cable support system, and a differential for synchronous motor starting or reduced voltage starter for induction motor starting. Point designs of 200 KWe, 500 KWe, and 1600 KWe were analyzed. C.K.D.

A79-40125 Development of the Variable Geometry Vertical Axis Windmill. P. J. Musgrove and I. D. Mays (Reading, University, Reading, England). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E4-39 to E4-60. 21 refs. Science Research Council Grant No. B/RG/92338.

The simplicity of the Variable Geometry Vertical Axis Windmill (VGVAW) makes it attractive for many applications, large scale and small. This paper concentrates on measurements that have been made on a 3-m-diam VGVAW prototype. Work on large-scale versions of

the design is proceeding separately in collaboration with industry. The performance of the 3-m low-solidity prototype has been measured in the open air, and a peak power coefficient of 0.30 to 0.35 recorded. This is in reasonable agreement with theoretical predictions and compares favorably with available open-air test data for Darrieus and horizontal-axis windmills. The choice of optimum solidity is discussed in some detail, and the effects of low aspect ratio considered. It is shown that low aspect ratio combined with high solidity can be expected to give aerodynamic self-start with only minor loss of performance. A low-aspect-ratio high-solidity vertical-axis windmill was therefore also constructed, and these expectations confirmed. (Author)

A79-40126 A new concept - The flexible blade windmill /FBW/. J. M. de Lagarde (Montpellier, Université, Montpellier, France). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E5-61 to E5-68.

A flexible-blade windmill has been designed and tested. The blades are made of light (20 kg per cu m) polyethylene plastic bonded to a leading edge of hollow light alloy extrusion and a trailing edge made of the same material or of rigid polystyrene sandwiched between aluminum sheets. The blade is drawn back by two elastic straps attached to the trailing edge and to fixed points on the back, and two mechanical stops limit the amplitude of blade motion, providing built-in variable geometry. An approach similar to that proposed by Templin (1974) has been used to study the torque coefficient of a single flexible blade as a function of the tip speed ratio. C.K.D.

A79-40127 Wind tunnel corrections for Savonius rotors. A. J. Alexander (Loughborough University of Technology, Loughborough, Leics., England). In: International Symposium on Wind Energy System, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. E6-69 to E6-80. 14 refs.

The work carried out by Maskell (1965), Gould (1970) and Cowdrey (1968), who have considered the flow about flat plates placed normal to the airflow in a closed wind tunnel, and Hackett (1976), who examined the case of aircraft models with large separated flow regions by representing them with line source-sink distributions whose strength is determined by wind tunnel measurements of wall static pressures, has been extended to obtain wind-tunnel corrections for Savonius rotor tests. Although the corrections are large for large blockage ratios, exceeding 50% for blockage ratios of 1/3, they have been confirmed by further test results. C.K.D.

A79-40128 Design and construction of a pilot plant for a shrouded wind turbine. O. Igra and K. Schulgasser (Negev, University, Beersheba, Israel). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. F1-1 to F1-12. 13 refs. Research supported by the U.S.-Israel Binational Science Foundation.

In continuation of past research with the shrouded wind-turbine concept, a pilot plant was designed and constructed for operation in the open atmosphere. For a 5-m/s free-stream wind, the 3-m-diameter shrouded turbine will generate about 1 kW. The shroud has a length of 8 m and maximum diameter of 6 m. The surface area of the shroud is about 220 sq m. The problem of maintaining this aerodynamically shaped envelope on its 10-m tower was solved by using two structural skeletons within the shroud envelope. A heavy skeleton of structural steel, consisting essentially of six pairs of hoops (squirrel cage) is anchored to the tower top and supports all rotating elements. To this is attached a lighter skeleton upon which the steel skin is fastened. This scheme was deemed optimum in that it made possible a reasonably light structure and minimized the

probability that damage to the shroud would cause damage to the rotating elements and their support. Some of the space within the shroud is used to contain the generator and its drive. (Author)

A79-40129 Tipvane research at the Delft University of Technology. T. van Holten (Delft, Technische Hogeschool, Delft, Netherlands). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. F2-13 to F2-24. 20 refs.

The paper presents some of the first results of experimental work done to verify the so called tipvane concept. Tipvanes are small auxiliary wings mounted at the tips of turbine blades in such a way that a diffuser effect is generated, resulting in a mass flow augmentation through the turbine disc. The first results have demonstrated mass flow augmentations by factors 4 or 5. A problem appears to be the reduction of viscous drag, since it has been found by boundary layer visualization that the boundary layers on the rotating vanes do not behave as would be expected from stationary windtunnel tests. As far as induced drag is concerned, visualization of the vortex system has shown that a strong beneficial vortex interaction occurs, just as was predicted by theory. (Author)

A79-40130 The regulation of an electricity supply system including wind energy generators. B. Sorensen (Copenhagen, University, Copenhagen, Denmark). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. G1-1 to G1-8. 8 refs.

Simulations are performed, of a system consisting of a number of fuel-based power generation units, plus wind energy generators without energy storage facilities. A simple wind forecasting technique, based on crude extrapolations, is used to predict the amount of base and intermediate load, that wind generators are expected to be able to replace. Decisions to start or stop fuel-based units are made on the basis of these predictions. If the predictions turn out to be in error, beyond the regulating capacity of the intermediate load fuel-fired units already in operation, use of peak load units or unplanned import is required. On the basis of hour-by-hour simulations throughout a year, the optimum share of wind generators in such a model system is discussed. (Author)

A79-40131 An economic model to establish the value of WECS to a utility system. E. E. Johanson and M. K. Goldenblatt (JBF Scientific Corp., Washington, D.C.). In: International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. G2-9 to G2-26.

An economic model developed to determine the value of wind energy conversion systems (WECS) to a utility is described. The method of establishing the value of WECS is discussed, noting that it will provide the amount that can be spent for its purchase by computing the savings from the WECS. The economic model was applied to a utility, and hourly load and wind data were used to conduct cost analysis both for the fuel saver mode and the reoptimized mix mode in which the WECS was integrated. It was found that the utility could spend \$792 per kW for a WECS complete installation and \$425 per kW for a WECS unit, and that less money was available to purchase it in the fuel saver than in the reoptimized mix mode. Sensitivity analyses showed that the value of the WECS is sensitive to the annual savings growth rate, land cost, capital cost, and the WECS availability, and insensitive to the tax rate, land values, and WECS economic lifetime. A.T.

A79-40132 Implications of large scale introduction of power from large wind energy conversion systems into the existing

electric power supply system in the Netherlands. G. H. Bontius, A. H. E. Manders, and T. Stoop (Keuring van Elektrotechnische Materialen, Arnhem, Netherlands). In: *International Symposium on Wind Energy Systems*, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. G3-27 to G3-38. 5 refs.

A79-40133 Wind energy - Heat generation. R. Matzen (Kongelige Veterinaer- og Landbohojskole, Copenhagen, Denmark). In: *International Symposium on Wind Energy Systems*, 2nd, Amsterdam, Netherlands, October 3-6, 1978, Proceedings. Volume 1. Cranfield, Beds., England, British Hydromechanics Research Association, 1978, p. H2-17 to H2-32. 5 refs.

A variety of water brakes were tested for a simple wind power plant designed to give 25,000 kWh of heat per year in the form of hot water. The prototype plant has a 6 m propeller with a tip speed ratio of 1:5. The plant is equipped with a gust safety system. Results for simple open impeller water brakes, open adjustable water brakes with movable stators, and closed adjustable water brakes with axle tightening are presented. On the basis of these results, a nomogram for dimensioning water brakes has been derived. C.K.D.

A79-40134 Air pollution control. H. E. Hesketh (Southern Illinois University, Carbondale, Ill.). Ann Arbor, Mich., Ann Arbor Science Publishers, Inc., 1979. 381 p. 171 refs. \$30.

The book presents theory and application data as related to air pollution control. A suitable background is provided relevant to behavior theories and control techniques for capturing gaseous and particulate air pollutants. The significant application data available are summarized and combined with the theories to provide a needed relation between the two. Numerous detailed example problems are worked throughout the book to serve as guides in the use of both the theoretical relationships and the data. General information on air pollution control is presented, with emphasis on what can be done to minimize pollution emissions while conserving energy. Problem areas of interest include particulate and gas control mechanisms, control devices, and control systems. S.D.

A79-40195 # Limit analysis and design of a semi-submerged concrete hull for an ocean thermal differences power plant. F. J. Dzialo and W. E. Heronemus (Massachusetts, University, Amherst, Mass.). (*American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.*) *ASME, Transactions, Journal of Energy Resources Technology*, vol. 101, June 1979, p. 93-98. NSF Grant No. GI-34979.

A79-40196 # Utilizing geothermal resources below 150 C /300 F. J. F. Kunze (Energy Services, Inc., Rexburg, Idaho). (*American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.*) *ASME, Transactions, Journal of Energy Resources Technology*, vol. 101, June 1979, p. 124-127. 5 refs.

Except for the steam-dominated geothermal field at Geysers, Calif., the use of geothermal energy in the U.S. has been minimal. There has been so much preoccupation with searching for the high temperature resources (above 350 F), for generating electricity, that the greatest potential for geothermal energy, that at temperatures below 150 C (300 F) has been largely ignored. These waters are much more abundant than the higher temperature ones, and therefore, represent 10 or more times as much usable energy than the total of the energy in all the high temperature waters. The problems have, in part, been technological - how to economically convert these lower temperature geothermal waters to useful energy - and in part institutional. This paper describes the last five year's program, largely centered at the Idaho National Engineering Laboratory, to make it more practical and economical to harness the lower temperature geothermal resources. (Author)

A79-40197 # Electrical production from moderate temperature geothermal brines. H. R. Jacobs and R. F. Boehm (Utah, University, Salt Lake City, Utah). (*American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.*) *ASME, Transactions, Journal of Energy Resources, Technology*, vol. 101, June 1979, p. 134-140. 12 refs. Research supported by the U.S. Department of Energy.

Direct contact binary cycles may be used to develop electrical power from moderate temperature geothermal brines. For a simple Rankine cycle using direct contact heat exchangers isobutane is preferred as a working fluid for brines at temperatures greater than 138 C. Pentane appears more attractive at lower temperatures. For all moderate temperature application, however, the use of bottoming cycles, multi-turbine, multifluid cycles, yields significantly better performance. (Author)

A79-40198 # Power extraction from ocean surface waves. D. G. Brown (Systems Engineering Associates, Atlanta, Ga.), D. Jones (Anow Manufacturing Co., Columbus, Ohio), and D. A. Guenther (Ohio State University, Columbus, Ohio). (*American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.*) *ASME, Transactions, Journal of Energy Resources Technology*, vol. 101, June 1979, p. 141-144. 12 refs.

This paper investigates the use of wave power as a viable energy source. A novel method for using a float to capture the power of waves is proposed, and the responses to a modeled sinusoidal wave form are analyzed. The responses of the system, determined experimentally and analytically, are correlated to illustrate that wave power can provide significant amounts of energy. The method analyzed, when employed on other float devices, increases the energy output of the system. (Author)

A79-40199 # Optimization of power absorption from sea waves. A. Baz, M. Ezz, and M. S. Bayoumi (Cairo, University, Cairo, Egypt). (*American Society of Mechanical Engineers, Energy Resources Technology Conference and Exhibition, Houston, Tex., Nov. 5-9, 1978.*) *ASME, Transactions, Journal of Energy Resources Technology*, vol. 101, June 1979, p. 145-152. 17 refs.

A generalized procedure for the rational selection of the design parameters of a simple wave power absorption system is presented. The system employs a tethered-symmetrical float which rides the seawaves and transmits the wave energy to a viscously damped load. The optimum load levels corresponding to the different sea states are determined for several float geometries in order to maximize the overall efficiency of wave-power conversion. The optimum float dimensions are constrained to guarantee that the float will not leave the wave crest during its upward travel or sink below the wave trough as it goes downward. The procedure also predicts, for different float configurations, the limits that, if satisfied, can guarantee that the system would operate at its maximum possible efficiency irrespective of the wave conditions. B.J.

A79-40251 Use of high-frequency electromagnetic waves for mapping an in situ coal gasification burn front. D. T. Davis, R. J. Lytle, and E. F. Laine (California, University, Livermore, Calif.). *In Situ*, vol. 3, no. 2, 1979, p. 95-119. 27 refs. Contract No. W-7405-eng-48.

High-frequency electromagnetic waves transmitted between boreholes can be used to map the position of an underground coal gasification (UCG) burn front, as well as other geophysical anomalies. The technique uses transmitting and receiving antennas lowered down boreholes on either side of the gasified region. Results from the use of this technique in a UCG experiment show high resolution and close agreement with data from thermocouples. The depth and height of the burn front were easily determined and subsidence of overburden was also evident in the measurements. Several variations on the method were tried. This technique promises several advantages over other down-hole instrumentation: lower cost, better spatial coverage, and the ability to give measurements both during and after passage of the burn front. (Author)

A79-40301 A generalized correlation of critical heat flux for the forced convection boiling in vertical uniformly heated round tubes - A supplementary report. Y. Katto (Tokyo, University, Tokyo, Japan). *International Journal of Heat and Mass Transfer*, vol. 22, June 1979, p. 783-794. 28 refs. Research supported by the Ministry of Education.

A79-40330 # Furnaces for experiments in zero-gravity conditions. J. P. Baselt, H. Kreeb, and H. François. *Dornier-Post* (English Edition), no. 3, 1979, p. 40-42.

Furnaces for materials research in zero gravity, during Spacelab missions, are discussed. The goal of these experiments will be to considerably improve material characteristics in the production of anorganic and organic crystals and materials for applications in electronics, and of metals and composite materials. Three types of furnaces are studied: (1) a mirror type furnace, primarily for crystal growing; (2) a gradient furnace for study of oriented solidification of liquified materials under micro-g conditions and their possible use for the growing of crystals; and (3) solar furnaces, which would result in a considerable relief of the onboard energy supply system and offer the additional advantages of attaining very high temperature by a suitable concentration of the solar radiation and melting of the samples without magnetic influences. M.E.P.

A79-40369 An analytical expression in terms of temperature only for optimising the flash cycle for geothermal power plants. D. J. Ryley (Liverpool, University, Liverpool, England). *Geothermics*, vol. 7, no. 1, 1978, p. 9-15.

A79-40370 The lithium-thionyl chloride battery - A review. R. Gangadharan, P. N. N. Nambodiri, K. V. Prasad, and R. Viswanathan (Central Electrochemical Research Institute, Karaikudi, India). *Journal of Power Sources*, vol. 4, Mar. 1979, p. 1-9. 37 refs.

The lithium-thionyl chloride nonaqueous cell system is a recent development. Low atomic weight and high electrode potential make lithium unique as an anode in energy devices. Preparation of the anode, cathode, and the electrolyte is reviewed. The construction of the cell, its performance characteristics, uses, etc., are also surveyed. (Author)

A79-40371 Advanced electrochemical energy sources for space power systems - A review. E. Hollax (Deutsche Akademie der Wissenschaften, Astronautische Gesellschaft, Berlin, East Germany). *Journal of Power Sources*, vol. 4, Mar. 1979, p. 11-19. 5 refs.

In the present paper, the state of the art of primary electrochemical systems, secondary electrochemical systems, and fuel cells is reviewed with a view toward the future. It is seen that the solar cell array/electrochemical storage battery power system will constitute the dominant power source for spacecraft. Nonrechargeable nonaqueous lithium batteries have emerged as a potential competitor to silver-zinc primary batteries. Also, the new nickel-hydrogen battery may well displace the Nicad storage systems. H₂/O₂ fuel cell systems employing alkaline or acid electrolyte are well suited for short-term high power demand missions. V.P.

A79-40372 Behavior of a sodium-sulfur cell with a dynamic sulfur electrode. B. Dunn and V. L. Sholtes (GE Corporate Research and Development Center, Schenectady, N.Y.). *Journal of Power Sources*, vol. 4, Mar. 1979, p. 33-41. 13 refs.

A sodium-sulfur cell was constructed with sodium polysulfide circulating in a narrow annulus around a beta-alumina tube. The absence of carbon mat in the electrode reduced the current collector surface area appreciably, localized the electrochemical reactions, and ultimately led to film formation on the electrode. The results are consistent with existing models and interpretations of sulfur electrode behavior. Film formation on the electrode is responsible for the rather poor electrical characteristics of the cell. (Author)

A79-40379 Concentrator for solar air heater. F. Demichelis and E. Minetti-Mezzetti (Torino, Politecnico, Turin, Italy). *Applied Physics*, vol. 19, July 1979, p. 265-268. 6 refs. Research supported by Fiat S.p.A.

A focusing collector for a solar air heater is examined in which Fresnel lenses comprise the concentrator and the absorbers are placed in an air duct. The absorbers consist of a set of blackbody metallic sheets having a suitable shape and mutual orientation enabling all incident and reflected energy to be trapped. A heat-transfer analysis shows that by using a convenient series of Fresnel lenses, an airstream of relatively high temperature can be obtained with a fluid flow rate of 150 kg/h and an efficiency of about 70% for an air-inlet temperature of approximately 20°C. F.G.M.

A79-40381 Boltzmann simulation of a storage ring laser. D. A. G. Deacon and J. M. J. Madey (Stanford University, Stanford, Calif.). *Applied Physics*, vol. 19, July 1979, p. 295-305. 14 refs. Research supported by the National Research Council of Canada; Grant No. DASG60-77-C-0083.

A numerical technique is described, which follows the motion of the entire electron distribution in a storage ring laser. The laser gain and electron distribution parameters such as energy spread, bunch length, damping rates, and containment time are discussed, both with and without the use of the gain expansion technique. The limits of validity of the one-dimensional approximation are defined. (Author)

A79-40386 Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. Conference sponsored by the American Society of Mechanical Engineers. New York, American Society of Mechanical Engineers, 1978. 578 p. \$45.

A series of papers on the conservation of energy through utilization of industrial and municipal waste products is presented. General topics include recovery of energy from solid waste products, air pollution control measures implemented in conjunction with waste recovery systems, processing and material recovery methods, legal and economic aspects of the development of waste utilization systems, the planning and operation of waste processing plants, liquid waste incineration, and research related to conservation of energy by waste utilization. C.K.D.

A79-40387 # Waste disposal by fluid bed incineration and energy recovery modes. H. S. Kwon (Dorr-Oliver, Inc., Stamford, Conn.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 1-10; Discussion, p. 11-13; Author's Reply, p. 13. 5 refs.

The application of fluid bed incineration in recovery of energy from a variety of waste types, including sewage sludge, domestic refuse and industrial waste, is discussed. Three incineration systems for sewage sludge are described: fluid bed incinerators with conventional dewatering (by vacuum filter or centrifuge) using a hot or cold windbox and a modified sewage sludge incineration system in which dewatering is accomplished by a filter press. The solid waste recycling plant in Franklin, Ohio, which handles pulped refuse or pulped refuse mixed with sludge, is discussed, with attention given to problems encountered in operation and their solutions. Incineration systems for treatment of pulp and paper mill waste liquor and refinery sludge are examined, and performance data for waste heat recovery systems for auxiliary fuel saving within the incinerator system, steam generation for external use, and combined operation are presented and compared. The problem of air pollution associated with waste disposal by fluid bed incineration is considered. C.K.D.

A79-40388 # Experience with solid waste as a supplementary fuel. J. E. Marshall (Imperial Metal Industries, Ltd., Birmingham, England). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 15-25; Discussion, p. 26, 27.

Design criteria used in development of a system employing municipal refuse to supplement energy from conventional fuels in the boiler plant of Imperial Metal Industries are discussed. Particular attention is given to the choice between firing shredded waste into a chain gate boiler or a cyclone boiler, and to the rationale of selection of a vertical rather than a horizontal shaft shredding machine. The shredding plant, capable of processing 15 tons/hr, is equipped for post-shredding magnetic separation of metal. Plastics and glass are not removed. No clinker or slag problems have been encountered. The shredded material is fired horizontally into the chain grate boilers. Experience has shown that optimal results are obtained with a particle size of 75 mm. The average moisture content of domestic refuse was found to vary from 20 to 50 percent. Because of excess moisture, refuse operations are discontinued at times of heavy rainfall. Freshly shredded refuse was found to give best results if held for 24 hours before incineration. Preliminary results of emissions studies indicate a slight drop in emissions when firing domestic refuse with respect to 100 percent coal. A savings of about \$15.83 per ton refuse was obtained.

C.K.D.

A79-40389 # Development of the Kiener pyrolysis system for environmental protection, energy recovery and recycling. F. Nowak. In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 29-41; Discussion, p. 42, 43; Author's Reply, p. 43, 44.

A pyrolysis system for volatilization and complete gasification of the organic component of domestic, commercial and industrial refuse is described. The system can be operated either for heat recovery and power production, or for production of raw materials for the chemical industry. Organic components of refuse are pyrolyzed in a rotating drum sloping along its longitudinal axis; pyrolysis takes place in an air-free atmosphere at temperatures of 400 to 500 C. Gases are passed through a cyclonic unit to remove soot and flyash and into the gas cracking and generating unit, where the temperature is raised to 1100 to 1200 C. After cracking the gases are passed through an incandescent layer of coal. The resulting mixture of hydrogen, carbon monoxide, simple hydrocarbons, carbon dioxide, nitrogen and small quantities of steam and heavy hydrocarbons is passed through a cyclonic gas cleaner and subjected to wet scrubbing. A fully automated pilot plant processing 200 kg of dry refuse per hour has been constructed. Data on the average composition of the gas produced, average grain distribution in residues from pyrolysis of domestic refuse and sludge, and analysis of the washwater are presented.

C.K.D.

A79-40390 # Considerations in the design of a shredded municipal refuse burning and heat recovery system. R. S. Rochford and S. J. Witkowski (Babcock and Wilcox Co., North Canton, Ohio). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 45-56; Discussion, p. 57, 58; Authors' Reply, p. 58, 59. 7 refs.

Factors affecting the design of a system to burn shredded municipal solid waste (MSW) and recover its heat values are discussed. A system based on a modern spreader stoker fired boiler burning refuse derived fuel (RDF) as a primary fuel is considered.

The influence of refuse analysis on the size and performance of refuse burning equipment is discussed. Special attention is given to selection of refuse feed systems and optimization of steam generating equipment. Factors affecting the selection and installation of electrostatic precipitators are considered, and systems for handling bottom ash and fly ash are described.

C.K.D.

A79-40391 # Handling and co-firing of shredded municipal refuse and coal in a spreader-stoker boiler. D. A. Vaughan, H. H. Krause, and W. K. Boyd (Battelle Columbus Laboratories, Columbus, Ohio). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 61-69; Discussion, p. 70; Authors' Reply, p. 70-72. 6 refs. U.S. Environmental Protection Agency Grant No. R-804008-2.

A79-40392 # Recycle energy system - City of Akron, Ohio. C. R. Glaus (Glaus, Pyle, Schomer, Burns and DeHaven, Inc., Akron, Ohio). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 73-82.

The Akron Recycle Energy System, a project designed to process 1,000 tons per day of municipal solid waste (MSW) for material recycling and production of steam, is described, and marketing concepts and project economics are discussed. The process consists of coarse single stage shredding of municipal, commercial and suitable industrial waste, combustion of the light fraction in semi-suspension fired boilers, recovery of ferrous metals, and future recovery of glass and aluminum. Gross steam production is projected to be 378,000 lb/hr, with a net production of 3.9 lb of steam per pound of solid waste received, corresponding to a boiler efficiency of about 78%. A multitiered group of steam consumers has been established to achieve 100% initial utilization of the steam produced. Schematic diagrams of the system are provided, and a typical mass and energy balance is presented.

C.K.D.

A79-40393 # Practice of heat utilization from refuse. W. J. Martin and H. Weiland (Josef Martin Co., Munich, West Germany). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 83-88; Discussion, p. 89; Authors' Reply, p. 89, 90.

The characteristics of five European incinerator plants for recovery of heat from municipal refuse are presented, and operational experience for the past three years is summarized. The quantity of light fuel oil saved by each plant is reported. The plants considered include: an incinerator with hot water production for district heating in Rennes (France); a heat and power station in Vienna-Spitellau (Austria) which produces hot water for district heating and electricity for in-plant requirements; the KEZO incinerator at Hinwil (Switzerland), associated with a power plant with condensing turbo-alternators; a heat and power station at Paris/Issy-les-Moulineaux (France) with back-pressure, condensing turbines, and steam export for district heating; and a plant in Munich-North II (Germany) in which refuse and pulverized coal are used to produce electricity and hot water for district heating.

C.K.D.

A79-40394 # Case study energy recovery from wastes from an automobile assembly plant. A. W. Johner (General Motors Corp., St. Louis, Mo.) and F. E. Wisely (Horner and Shifrin, Inc., St. Louis, Mo.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 91-97; Discussion, p. 98, 99.

The recovery of energy from automobile plant wastes, including general plant wastes, wood, paint sludges, flammable liquids and shredded cardboard is discussed. The relative advantages and disadvantages of three possible energy recovery systems, including use of shredded wastes as fuel in existing coal-fired boilers, use of modular burning units equipped with waste heat boilers to provide steam for the existing steam system, and a composite approach using the primary combustion chambers of the modular units to provide a hot, partially combusted gas to existing plant boilers, are considered. An energy recovery system based on the second option is described, and cost benefits to be derived from processing 150 tons of raw waste per day are estimated. Estimated annual costs and credits for operation of such a plant in 1979 are compared with projected figures for 1984. C.K.D.

A79-40395 # Properties and operating experience with bagasse as a boiler fuel. T. N. Adams (British Columbia, University, Vancouver, Canada), G. D. Whitehouse, and D. Maples (Louisiana State University, Baton Rouge, La.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 101-106. 10 refs.

Results obtained in investigations of the properties of bagasse as a boiler fuel are reviewed and analyzed. The heating value of dry, ash-free bagasse from a broad geographical region within Louisiana is about 8300 Btu/lb. Ash content ranges from 4 to 18 percent, with an intrinsic ash content (ash associated with the cane) between 1 and 2 percent. The sulfated ash determination is found to overestimate the quantity of zero-heating-value material by about 50 percent. Tramp air entering through open feed-chutes accounts for a portion of the high excess air found in cell furnaces; cells in bagasse furnace operate with 60 to 65 percent excess air, tramp air excluded. Although effective utilization of bagasse in spreader-stoker furnaces has been demonstrated in some instances, it has been found that the performance of these units is seriously prejudiced by inadequate turbulence levels and improper fuel distribution. C.K.D.

A79-40396 # Use of waste wood in plywood manufacture - A case history. G. G. Cameron (SWF Plywood Co., Albany, Ore.), G. Grimes (SWF Plywood Co., Medford, Ore.), and L. G. Desmon (Energex, Ltd., Portland, Ore.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 107-113; Discussion, p. 114; Authors' Reply, p. 114, 115. Starting with two suspension burners in 1974, seven additional double vortex wood waste fuel burners have been installed as heat sources for veneer dryers to: (1) dispose of wood waste; (2) decrease dependency upon fossil fuels; (3) provide a degree of hydrocarbon emission control, and (4) reduce fuel costs. In 1976, five plants used 13.9 million therms (1467 TJ) to dry veneer and make plywood from it. A total of 8.2 million therms (865 TJ) came from wood waste. Approximately 60 percent of all energy used, exclusive of electricity, was derived from wood wastes generated in the manufacture of plywood. (Author)

A79-40397 # 308 billion ton-hours of refuse power experience - A review of the long-term operating record at Dusseldorf city. K. S. Feindler (Grumman Ecosystems Corp., Melville, N.Y.) and K. H. Thoenen (Stadtwerke Düsseldorf AG, Düsseldorf, West Germany). In: Energy conservation through waste utilization; Proceed-

ings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 117-156; Discussion, p. 157. 15 refs.

The design and operation of the Fliegers Refuse Power Plant in Dusseldorf, West Germany, which provides refuse-derived steam for the cogeneration of electricity and for district heating, are described in detail. The plant has a production capacity of 2,900 tons per day of superheated steam, produced by combustion of 1400 tons per day of refuse on a specially designed roller grate system having variable speed drive and variable delivery air supply to ensure maximum performance. The evolution of the plant design is outlined, and the operating economics of the plant are discussed in depth. Data for a ten-year period (1966-1976) are presented on the annual flow of energy and materials, the prices of energy and materials, the annual income and expenses of the plant, and specific expenses incurred in operation of the power plant. The plant energy budget for 1976 is given, together with a breakdown of internal electric power consumption and user characteristics. Performance data and major performance parameters are provided and compared with performance data for nuclear fueled plants and other refuse fired plants. The characteristics of municipal refuse in Europe and the United States are compared. C.K.D.

A79-40398 # Integrating an electrostatic precipitator into a municipal solid waste resource recovery system. J. Peacy (UOP, Inc., Des Plaines, Ill.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 159-165; Discussion, p. 166; Author's Reply, p. 166. 9 refs.

A79-40399 # Flue gas emissions from a shredded-municipal-refuse-fired steam generator. R. S. Reid and D. H. Heber (Winzler and Kelly, Eureka, Calif.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 167-177; Discussion, p. 178. 5 refs.

A79-40402 # RDF storage and retrieval problems: Cause - effect - options. H. G. Lisiecki (Rexnord, Inc., Milwaukee, Wis.). In: Materials problems in gas turbine engine technology; Colloquium, Munich, West Germany, October 27, 28, 1977, Report. Karlsruhe, Werkstofftechnische Verlagsgesellschaft mbH, 1978, p. 199-204; Discussion, p. 205; Author's Reply, p. 205, 206.

The problem of material compaction in municipal waste stored for eventual use as refuse-derived fuel is examined. It is suggested that this problem can best be handled by use of live bottom bins, which would consist of a series of 12 ft wide apron conveyors forming a live storage area across the bottom of the storage structure, with similar retrieval conveyors elevating the refuse from this structure opposite the loading point. The design and operation of such a system are described. C.K.D.

A79-40404 # Air classify first, then shred. A. R. Nollet and E. T. Sherwin (AENCO, Inc., New Castle, Del.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 229-238; Discussion, p. 239-242; Authors' Reply, p. 242-248. 9 refs.

As the result of numerous explosions experienced in a waste processing and resource recovery plant in which refuse was shredded prior to separation, a system permitting separation to be carried out as a first step before shredding was tested. The system utilizes a 40-foot long rotary drum separator with a diameter of 20 feet. The drum, which is inclined at an angle with the horizontal, repeatedly

drops refuse through an air stream, which carries the light fraction to a de-entrainment plenum. The heavy fraction, representing 30% by weight and 10% by volume, is screwed out of the lower end of the drum. Installation of an operational system is planned. C.K.D.

A79-40406 # The economics of energy recovery from industrial waste incineration. W. K. Lombard (Trecan, Ltd., Mississauga, Ontario, Canada). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 263-274; Discussion, p. 275, 276; Author's Reply, p. 276.

The types of solid, liquid and gaseous wastes typical of industrial plants are discussed, and the incineration and heat recovery systems appropriate to their processing are described. An approach to evaluation of the economic feasibility of installing an energy recovery system utilizing given quantities and types of industrial waste is presented. The proposed approach is based on a 'justification factor', defined as the cost of equipment and installation divided by the difference between savings factors (cost of equivalent purchased fuel and waste removal costs) and cost factors (incinerator fuel, maintenance labor and ash removal costs for solid wastes). Projected 1980 justification factors and 1977 justification factors for several different combinations of hours of use and tons per day of solid or liquid waste are presented. C.K.D.

A79-40407 # Economic factors in refuse derived fuel utilization. J. L. Rose (Syska and Hennessy, Inc., New York, N.Y.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 277-284; Discussion, p. 285, 286; Author's Reply, p. 286.

The utilization of refuse derived fuels (RDF) in conjunction with fossil fuels involves the evaluation of a number of unusual economic factors. These include age, efficiency, capacity factor and remaining service life of the plant accepting the RDF, and the effect of burning RDF on these factors. A methodology is presented which results in a realistic appraisal of the value of RDF at any particular site. (Author)

A79-40408 # Elements of financial risk - Identification of major elements affecting financial risk in the financing of solid waste resource recovery projects. J. F. Clunie and R. G. Taylor (R. W. Beck and Associates, Wellesley, Mass.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 287-293; Discussion, p. 294-296.

A79-40410 # Research and development facilities at the Ontario Center for Resource Recovery. N. R. Ahlberg and B. I. Boyko (Ontario Ministry of the Environment, Downsview, Canada). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 341-349.

The paper describes a production-size research and development facility for resource recovery technologies administered by the Ontario Ministry of the Environment. The plant, designed to process an average of 40 t/hour of municipal refuse, comprises a scalehouse, receiving, transfer and paper recovery facility, shredding and air classification and separation buildings, a commodity and energy recovery unit, and a composting facility. The main shredder is a 1000 hp horizontal shaft hammermill with a peak capacity of 60 t/hr. Ferrous metals are recovered magnetically after separation of the light fraction and shredded for shipment. A pulsed jet baghouse

controls particulate emissions from the air separator and classifier. Glass and organics are separated by screening. The energy recovery system consists of a modular starved air incinerator with a waste heat boiler yielding low pressure hot water for plant heating from either the light or the organic fraction of the refuse. The organic fraction, together with the clean fiber fraction, is alternatively used for production of compost in an aerobic digester. Marketing and market development programs have been undertaken for plant products.

C.K.D.

A79-40412 # Heating value of refuse derived fuel. S. T. Mrus (Burns and Roe Industrial Services Corp., Paramus, N.J.) and C. A. Prendergast (DSI/Resource Systems Group, Inc., Boston, Mass.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 365-370; Discussion, p. 371; Authors' Reply, p. 371, 372. 10 refs.

A79-40413 # Pyrolysis, thermal gasification, and liquefaction of solid wastes and residues - Worldwide status of processes /as of Fall 1977/. J. L. Jones, R. C. Phillips (SRI International, Menlo Park, Calif.), S. Takaoka (SRI International, Tokyo, Japan), and F. M. Lewis (Deutsche Anlagen Miete GmbH, Mainz, West Germany). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 387-396. Navy-supported research.

A79-40414 # Comparison of refuse derived fuel (RDF) characteristics between two Pennsylvania communities. R. J. Schoenberger, J. Gibbs (Drexel University, Philadelphia, Pa.), J. K. Sonstebly (Pennsylvania Power and Light Co., Allentown, Pa.), A. M. Arndt (Lehigh County Authority, Wescosville, Pa.), and R. M. Gruninger (Malcolm Pirnie, Inc., Paramus, N.J.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 397-407. 10 refs.

A79-40415 # Solid waste utilization in integrated community energy systems. T. J. Marciniak and R. E. Holtz (Argonne National Laboratory, Argonne, Ill.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 409-418. 9 refs.

The application of two solid waste utilization technologies - incineration with heat recovery and pyrolysis - in Integrated Community Energy Systems (ICES) serving communities of 1000 to 100,000 inhabitants is considered. The suitability of two incinerator types (two-chamber incinerators and incinerators with waterwall design for heat recovery or heat exchangers in the fuel gas stream) and four pyrolysis systems (Occidental, Purox, Landgard and RefuCyler) for use in ICES is examined. Design and cost parameters are presented for systems using solid waste to supply energy for a 115-acre shopping center and a 725-acre new community. Two designs are considered in detail: a system based on current technology in which a bank of diesel engines is used to meet the electricity requirements of the center while waste heat is used for space heating and cooling of the center and surrounding community; and a system based on advanced fuel technology. Results indicate that solid waste generated within a residential/commercial community can meet about 3 to 5% of the total fuel demand. Systems incorporating solid waste pyrolysis units appear to be economically viable if disposal costs exceed \$20/ton. C.K.D.

A79-40416 # Utilization of fluidized bed combustion in energy recovery from solid wastes. J. R. Hamm and D. L. Kearns (Westinghouse Research and Development Center, Pittsburgh, Pa.).

In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 419-425. 14 refs.

Fluidized bed combustion is capable of utilizing a wider variety of fuels (including solid wastes) than is any other combustion process. Thus, it has the potential for wide application in systems for recovering energy from solid wastes in industry, commercial sites, institutions, forestry, and agriculture to produce electric power, process steam, process heat, and space heating. Three fluidized bed combustion concepts are identified for near-term application: atmospheric fluidized bed boiler, exhaust-heated gas turbine or combined cycle, and closed-cycle gas turbine. (Author)

A79-40417 # Design criteria to achieve industrial power plant reliability in solid waste processing plants with energy recovery. G. Stabenow (UOP, Inc., Stroudsburg, Pa.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 427-441; Discussion, p. 442, 443; Author's Reply, p. 443-446.

A79-40418 # An overview of San Diego County's resource recovery plant. A. K. Chatterjee (Acres American, Inc., Buffalo, N.Y.) and Y. Garbe (U.S. Environmental Protection Agency, Washington, D.C.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 447-453; Discussion, p. 454; Authors' Reply, p. 454, 455. Research supported by the U.S. Environmental Protection Agency.

San Diego County's resource recovery plant is designed to process 200 tons per day (181.5 t/day) of municipal solid waste in a flash pyrolysis system to produce 200 barrels of synthetic oil, 15 tons (13.6 t) of ferrous metals, 10.7 tons (9.71 t) mixed colored glass and 1.2 tons (1.09 t) of nonferrous metals. This paper describes the flash pyrolysis process, including the major system components and their individual functions. Capital outlays, financial participation, and the plant shutdown, startup and operating data will also be discussed. (Author)

A79-40419 # Refuse shredding - Performance, testing and evaluation data. C. R. Liddell, R. H. Brickner, and W. D. Heyer (Allis-Chalmers Corp., Appleton, Wis.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 457-462; Discussion, p. 463, 464. 7 refs.

The energy required to shred municipal solid waste containing a wide variety of material was investigated at the refuse processing plant in Outagamie County, Wisconsin, and the effect of rotor speed modifications on system energy requirements was determined. The system comprises two horizontal design shredders with four rows of pivoting hammers each, providing three-step size reduction by shattering, shearing and a combination of impacting, shearing and grinding to give an end product with a nominal particle size of 3 in. An energy savings of 1.47 kWh/ton was obtained by reducing rotor speed from 1000 rpm to 900 rpm, with no effect on system capacity. A slight increase in particle size was observed. Grate configuration tests showed that the grate open area and grate arc of the shredder strongly affect system performance. Power consumption was found to decrease and particle size to increase, as grate bars are removed from the shredder. C.K.D.

A79-40420 # A technical and economic evaluation of the Baltimore Landgard demonstration. A. J. Helmstetter (Systems Technology Corp., Xenia, Ohio) and D. B. Sussman (U.S. Environmental Protection Agency, Washington, D.C.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial

National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 465-474; Discussion, p. 475; Authors' Reply, p. 475. U.S. Environmental Protection Agency Contract No. 68-01-4359.

Results of a technical and economic evaluation of the Baltimore Landgard Plant, a full-scale processing plant designed to demonstrate the feasibility of using pyrolysis as an integral step in the recovery of energy, glassy aggregate, and magnetic metals from a mixed municipal solid waste stream, are presented. As designed, the unit was to process 1000 tons per day of solid waste and yield 80 tons of carbon char for landfill, 70 tons of ferrous metal, 169 tons of glassy aggregate for use in road building, and 4.8 million lbs of steam, with the remaining 80 tons of residue going to landfill. The off-gas from the pyrolysis reaction was burned in a high temperature afterburner, discharged through waste heat boilers and cleaned by a wet scrubber before release to the environment. However, numerous difficulties were encountered in operation, including problems with kiln control, residue slagging in the kiln, refractory failures, wastage of fans and pumps, ram feeder jams, slag tap hole pluggage, and poor performance of the shredded waste storage and recovery systems. These problems are discussed, and a summary of heat and material balance for the process is presented together with an economic evaluation of the plant. Although the technical feasibility of the process was demonstrated, the net cost of operations was shown to exceed \$49.00 per ton of waste input. C.K.D.

A79-40422 # Evaluation of densified refuse derived fuels for use in pulverized coal-fired steam generators. N. J. Stevens and J. C. Guillaumin (Detroit Edison Co., Detroit, Mich.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 491-503; Discussion, p. 504. 6 refs.

A79-40424 # Planning for resource recovery in the 'Big Apple'. L. F. O'Reilly (Leonard F. O'Reilly and Associates, Inc., Montclair, N.J.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 511-519; Discussion, p. 520; Author's Reply, p. 520, 521. 10 refs.

This paper presents the full scope of the City of New York's first Masterplan for resource recovery from the 30,000 (27,225 t) tons per day of refuse generated by its 7.9 million citizens. The plan envisions eleven projects ranging between 400 and 2000 tons (360 and 1815 t) per day capacity including recovery from water walled incineration, pyrolysis, refuse derived fuel, material recovery and compost. The paper includes financial, public relations, and marketing aspects of solid waste management as well as technology selection. (Author)

A79-40425 # Oceanside Disposal Plant improvement program - Design, construction and operating experience. R. S. Hecklinger, C. O. Velzy, and W. B. Trautwein (Charles R. Velzy Associates, Inc., Armonk, N.Y.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978.

New York, American Society of Mechanical Engineers, 1978, p. 523-530; Discussion, p. 531; Authors' Reply, p. 531. 11 refs.

The Oceanside Disposal Plant, Town of Hempstead, Long Island, New York, was commissioned in 1965 to produce steam and electrical power from combustion of municipal solid waste. Early in operation, unexpected problems developed which limited plant capacity. In 1970, an improvement program was undertaken to upgrade plant performance and availability. The first unit that was improved has been operating since 1974. The other two improved units were placed in operation in 1977. General data on design, construction and operating experience during the program is pre-

sented and specific information is given regarding boiler tube life, air pollution control, and design considerations in the combustion zone. (Author)

A79-40426 # Utilization of sewage skimmings as fuel to generate process steam. R. C. Petura, C. R. Brunner, and R. F. Bonner, Jr. (Malcolm Pirnie, Inc., White Plains, N.Y.). In: Energy conservation through waste utilization; Proceedings of the Eighth Biennial National Waste Processing Conference, Chicago, Ill., May 7-10, 1978. New York, American Society of Mechanical Engineers, 1978, p. 533-539; Discussion, p. 540, 541; Authors' Reply, p. 541.

Heretofore, disposal of sewage scum or skimmings from the settling tanks of waste water treatment plants has been by incineration in conjunction with other plant wastes. These skimmings are rich in hydrocarbons but high in moisture content, and with proper preparation and dewatering they become a source of energy for use as fuel in the generation of steam for process use and building heating. In conjunction with the addition of tertiary treatment at the Southerly Wastewater Treatment Plant of the Cleveland Regional Sewer District, a steam-generating unit fired with skimmings as the fuel source is used to provide the 425-psig (2.93-MPa) saturated steam needed in the thermal conditioning process. This paper presents the design parameters for this special steam-generating unit and its air pollution control equipment. (Author)

A79-40451 Particle size variation in the solvent refined coal process. C. W. Curtis, A. R. Tarrer, and J. A. Guin (Auburn University, Auburn, Ala.). *I & EC - Industrial and Engineering Chemistry, Process Design and Development*, vol. 18, July 1979, p. 377-385. 13 refs. Contract No. EX-76-S-01-2454.

This paper presents a method, based upon Coulter Counter utilization, for determination of the particle size distribution of solids in solvent refined coal (SRC) process streams. Several particle size distributions from batch autoclave experiments are followed through the dissolution process. Particle size distributions from the Wilsonville, Ala., SRC pilot plant are compared with those from the autoclave reactors for four different coals. The mean particle size in the SRC reactor effluent is found to provide a reliable index of downstream filterability. (Author)

A79-40452 Pyrolysis of Western Kentucky heavy oil using a transfer line reactor. S. Krishnamurthy, Y. T. Shah (Pittsburgh, University, Pittsburgh, Pa.), and G. J. Stiegel (U.S. Department of Energy, Pittsburgh Energy Technology Center, Pittsburgh, Pa.). *I & EC - Industrial and Engineering Chemistry, Process Design and Development*, vol. 18, July 1979, p. 466-474. 17 refs. Contract No. EY-77-S-02-4083.

The pyrolysis of a heavy fraction of the COED Western Kentucky coal oil was studied using a transfer line reactor at temperatures ranging from 600 to 750 C, with pressures of essentially 1 atm and residence times up to 0.1 s. Results indicate the preferential pyrolysis of the saturates fraction in the oil. The main gas products are hydrogen, methane, and ethylene whose formation is favored by increasing temperatures and residence times. The formation of polycyclic aromatics is evident in the liquid pyrolysate at high temperatures and long residence times. The rate of cracking of the heavy oil was found to follow first-order kinetics with an activation energy of 16,947 cal/g-mol. A comparison is made with the results reported earlier for the pyrolysis of a light fraction of the COED Western Kentucky coal oil (Krishnamurthy et al., 1979). The light oil, due to its lower boiling range and higher saturates content, yields more gaseous hydrocarbons and appears to be less susceptible to polymerization than the heavy oil under similar conditions. (Author)

A79-40453 Noncatalytic coal liquefaction in a donor solvent - Rate of formation of oil, asphaltene, and preasphaltenes. M. A. Shalabi, R. M. Baldwin, R. L. Bain, J. H. Gary, and J. O. Golden (Colorado School of Mines, Golden, Colo.). *I & EC -*

Industrial and Engineering Chemistry, Process Design and Development, vol. 18, July 1979, p. 474-479. 13 refs. Research supported by the U.S. Department of Energy.

Rates of formation of oil, asphaltene, and preasphaltenes during solvent extraction of a high-volatile A bituminous coal have been experimentally determined. A mathematical model that adequately describes the observed data has been developed, and pseudo-first-order rate constants for each of the indicated mechanistic steps have been calculated by nonlinear regression. The results of the study show rapid conversion of the reactive maceral fraction of the coal to liquid products and indicate that stable intermediates which are resistant to further hydrogenation at solvent-refining conditions are present in the reactor at long reaction times. (Author)

A79-40454 Process aging studies in the conversion of methanol to gasoline in a fixed bed reactor. S. Yurchak, S. E. Voltz, and J. P. Warner (Mobil Research and Development Corp., Paulsboro, N.J.). *I & EC - Industrial and Engineering Chemistry, Process Design and Development*, vol. 18, July 1979, p. 527-534. 9 refs. Research supported by the Mobil Research and Development Corp.; Contract No. E(49-18)-1773.

Catalyst aging studies of the methanol-to-gasoline process were conducted in an adiabatic fixed bed unit. An aging test of over 200 days on stream was achieved during which 8000 lb of methanol/lb of conversion catalyst was processed. Catalyst activity was still satisfactory at the end of the aging test. Some changes in product selectivities were observed during individual cycles and from cycle to cycle. The properties of the methanol-derived gasoline are generally comparable to those of commercially marketed gasolines. Combination of this process with the commercially available coal-to-methanol technology provides an alternate route for the conversion of coal to high octane gasoline. (Author)

A79-40455 Coal liquefaction and deashing studies. I - Consol Synthetic Fuel process. II - Solvent Refined Coal process. J. A. Kleinpeter, D. C. Jones, P. J. Dudd, and F. P. Burke (Conoco Coal Development Co., Library, Pa.). (*American Institute of Chemical Engineers, National Meeting, 85th, Philadelphia, Pa., June 4-8, 1978.*) *I & EC - Industrial and Engineering Chemistry, Process Design and Development*, vol. 18, July 1979, p. 535-546. 12 refs. Contract No. EX-76-C-01-1517.

Pittsburgh Seam 8 coal was liquefied by the Consol Synthetic Fuel (CSF) donor solvent process and deashed via gravity settling at 600 F with and without an anti-solvent. These continuous 10 lb/hr tests were done to provide guidance for the 20 TPD Cresap CSF Pilot Plant. Mass spectral and NMR analyses showed that the CSF solvent closely approached steady state operation and that tetralins, hydrophenanthrenes and hydroxyrenes were the predominant hydrogen donors. Integrated gravity settling produced 0.22 wt % ash extract, and the settler upflow velocity of 0.3 in./min translates to 34 40-ft diameter settlers for a 25,000 TPD commercial plant. Using paraffinic anti-solvent to precipitate a fraction of the coal extract to enhance settling gave little improvement in solids removal and massive agglomerates formed at a moderate anti-solvent rate and forced shutdown of the rake-equipped settler. Settler performance improved as the liquefaction solvent approached steady-state composition and with increasing liquefaction solvent/coal ratio. Earlier CSF liquefaction and gravity settling deashing studies achieved four times the ash removal rate and a lower ash content which may have resulted from the use of the liquefaction solvent which was further from steady state than in this experiment. The Ft. Lewis Solvent Refined Coal (SRC) Pilot Plant was simulated in a 10 lb coal/hr unit using equilibrium pilot plant solvent and Kentucky 9.14 coal, with integrated gravity settling deashing producing 0.1 wt % ash SRC for anti-solvent/liquefaction ratios of 0.3-0.5. A.T.

A79-40456 A stoichiometric analysis of coal gasification. J. Wei (MIT, Cambridge, Mass.). *I & EC - Industrial and Engineering Chemistry, Process Design and Development*, vol. 18, July 1979, p. 554-558. 12 refs. Research supported by the Electric Power Research Institute.

Many reactions take place inside a coal gasification process, which is very complex to analyze. However, the overall change and product distribution are severely constrained and simplified by considerations of stoichiometry. The overall results can be reduced to the nonnegative (zero or positive) sum of six basis reactions, and in the absence of significant methane formation, four basis reactions are sufficient. A consideration of thermal balance between the exothermic and the endothermic reactions further constrains the results to a thermal balanced plane or line. A comparison with full-scale and pilot-plant data shows that the product distributions fall on a predictable narrow band, based on mass and energy balance considerations alone before any considerations of thermodynamic equilibrium, reaction kinetics, reactor design, and operation.

(Author)

A79-40490 * # **New energy conversion techniques in space, applicable to propulsion.** A. Hertzberg (Washington, University, Seattle, Wash.) and K. C. Sun (Lockheed Research Laboratories, Palo Alto, Calif.). *AIAA, SAE, and ASME, Joint Propulsion Conference, 15th, Las Vegas, Nev., June 18-20, 1979, AIAA Paper 79-1338.* 43 p. 25 refs. Grant No. NGL-48-002-044.

The powering of aircraft with laser energy from a solar power satellite may be a promising new approach to the critical problem of the rising cost of fuel for aircraft transportation systems. The result is a nearly fuelless, pollution-free flight transportation system which is cost-competitive with the fuel-conservative airplane of the future. The major components of this flight system include a laser power satellite, relay satellites, laser-powered turbopumps and a conventional airframe. The relay satellites are orbiting optical systems which intercept the beam from a power satellite and refocus and redirect the beam to its next target.

(Author)

A79-40587 **Conservation of satellite transmitter energy with propagation and demand variations.** J. J. Metzner (Wayne State University, Detroit, Mich.). In: *NTC '78; National Telecommunications Conference, Birmingham, Ala., December 3-6, 1978, Conference Record, Volume 3.* Piscataway, N.J., Institute of Electrical and Electronics Engineers, Inc., 1978; p. 40.6.1-40.6.5. 8 refs. NSF Grant No. ENG-75-07839.

This paper is concerned with the discussion and evaluation of strategies which may significantly reduce satellite average power requirements for data communication with propagation and demand fluctuations. Assumptions of signal- and message-processing capabilities beyond current practice are made. Also, an unconventional downlink modulation format which emphasizes transmitted energy usage roughly proportional to amount of data transmitted is assumed. A cost function is studied which weighs energy utilization and delay costs. During a period of poor communication conditions the bit rate per watt of transmitter power can be much less than when conditions are good. Thus, there is a conflict between delay costs and a desire to save energy by holding data while awaiting better channel conditions. Cost minimization conditions are derived for a simplified channel model. Assumption of an exponential delay cost function has some realistic features and leads to a compact mathematical result.

(Author)

A79-40675 **Solar collector development in Iran.** A. E. Dabiri, F. Bahar (Arya Mehr University of Technology, Teheran, Iran), and G. Grossman (Technion - Israel Institute of Technology, Haifa, Israel). *Sunworld*, vol. 3, no. 3, 1979, p. 70-74. 9 refs.

Part of a solar energy program initiated to develop solar domestic applications in Iran is described. Three flat plate and one concentrating solar collector are presented in design. Collector construction followed two guidelines: First, the collectors were to be suitable for manufacturing from readily available materials by unsophisticated industry. Second, they were to be easily installed by unskilled people and designed to fit already existing plumbing systems, where necessary. Collectors 1 and 2 consisted of galvanized steel pipes with straps welded between, and a flat plate fastened behind, the pipes, respectively. Collector 3 consisted of a corrugated black iron sheet spot welded to a flat black iron sheet. A

concentrating cylinder consisting of a parabolic reflector and a glass-tube-enclosed collector pipe was the fourth test collector. Test procedure is detailed along with the formula for calculating collector efficiency. Test data are presented and it was found that efficiencies up to 70% were obtained, in good agreement with numerical calculations based on a heat transfer analysis.

M.E.P.

A79-40699 # **Economic and environmental impacts of a U.S. nuclear moratorium, 1985-2010 /2nd edition/.** C. E. Whittle, E. L. Allen, C. L. Cooper, F. C. Edmonds, J. A. Edmonds, H. G. MacPherson, D. L. Phung, A. D. Poole, W. G. Pollard, and D. B. Reister. Research supported by the National Research Council and U.S. Department of Energy; Contract No. EY-76-C-05-0033. Cambridge, Mass., MIT Press, 1979. 421 p. 266 refs. \$17.50.

Based on a projection of economic growth and energy production during the next thirty years, the present study investigates five possible economic implications of a nuclear-power moratorium: future costs of electricity, regional dislocations, impact on the nuclear industry, effect on the coal industry, and impact abroad. The book also examines four levels of environmental tradeoffs as a result of shifting the additional fuel requirements from nuclear to coal after 1985: proliferation of nuclear weapons and increased CO₂ from fossil fuel on a global scale, probability of reactor and coal mining accidents, impact of reactor radiation emissions and coal-fired emissions on public health, and impact of uranium and coal mining on land use. Speculations are presented on the distant nonfossil future when nuclear or solar energy may be the only major long-term energy options. A major finding of the study is that the rate of growth in energy demand is likely to be significantly lower than the projected estimates in most published studies.

B.J.

A79-40719 **Electrical power distribution subsystem.** G. Bolton and H. van Looij (ESA, European Space Research and Technology Centre, Noordwijk, Netherlands). In: *Spacelab: Utilization and experimental design; Course on Space Technology, Toulouse, France, May 22-June 2, 1978, Proceedings.*

Toulouse, Centre National d'Etudes Spatiales, 1979, p. 301-335.

The power distribution and allocation subsystem for the Orbiter, Spacelab, and the Spacelab payload is discussed, and the effect of the electromagnetic environment on the Spacelab payload is considered. The electrical power source on the Orbiter, shared by Skylab, is a set of three oxygen/hydrogen fuel cells, supplying an average of 7 kW each, with a peak energy of 12 kW. The Spacelab payload is allocated 15 to 25% of the available power. The main bus system on Skylab distributes power at 28 volts dc. A second bus distributes 400 HZ ac at 115 volts to subsystems and experimenters. The bus system is described, together with the subsystem power distribution box, experiment power distribution box, experiment power switching panel, monitoring and control panel, and inverters. Special attention is given to the monitoring and control systems. Schematic diagrams of most systems are provided.

C.K.D.

A79-40736 **Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978.** Symposium sponsored by the Chemical Institute of Canada, Alberta Energy Co., Department of Energy, Mines and Resources of Canada, et al. Edited by M. Tomlinson (Whiteshell Nuclear Research Establishment, Pinawa, Manitoba, Canada). Washington, D.C., American Chemical Society (ACS Symposium Series, No. 90), 1979. 363 p. \$25.

The chemistry of various sectors of energy production from Canadian sources is reviewed, and important R&D areas are identified. This 20-chapter book is divided into three main sections: fossil fuels, perpetual and renewable sources, and electricity production and storage. The fossil fuel section covers coal conversion, oil sands, sulfurization, peat, and the Canadian government's R&D program as well as Canada's fossil fuel resources. Under renewable resources, the potential of biomass is discussed, with emphasis on the most energy-efficient and least costly use of biomass, the direct

burning of wood. The uses of anaerobic bacterial systems for conversion of animal manure into methane are examined along with the interaction of photosynthetic and sulfate-reducing bacteria in a membrane-separated anaerobic culture. Some of the chemical problems encountered during nuclear generation of electricity are considered. Solar energy is related to the thermodynamic and kinetic limits on its conversion and storage. S.D.

A79-40737 # Prospects for coal conversion in Canada. N. Berkowitz (Alberta Research Council, Edmonton, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 11-27, 32 refs.

The rapid rise in natural gas and oil prices has brought coal into focus as a resource from which petrochemical feedstocks, fuel gas and synthetic liquid hydrocarbons could be produced in future. The paper discusses the chemistry of coal gasification and liquefaction, the current status of conversion processes and the effects of coal properties on coal performance in such processes. Attention is given to an examination of the contributions which coal conversion could make toward achieving Canadian energy self-sufficiency. Also discussed are a possible role for the medium-Btu gas in long-term supply of fuel gas to residential and industrial consumers, pertinent linkages between partial conversion and thermal generation of electric energy, and the coproduction of certain petrochemicals, fuel gas and liquid hydrocarbons by carbon monoxide hydrogenation. S.D.

A79-40738 # The AOSTRA role in developing energy from Alberta oil sands. R. D. Humphreys (Alberta Oil Sands Technology and Research Authority, Edmonton, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 28-32.

The paper discusses the role of the crown corporation AOSTRA (Alberta Oil Sands Technology and Research Authority) in developing energy from the oil sands located in the northern section of Alberta. The objective of the Authority is to develop economically and environmentally acceptable technology through collaborative action by industry, university and government. This major objective is then subdivided into two categories, requirements and needs. The discussion covers the methodology for carrying out the objectives through collaborative work, in situ technology, mining improvements, upgrading bitumen, underground mining, technology ownership and appropriate funding. AOSTRA now has four in situ field projects under way. S.D.

A79-40739 # The relation of surfactant properties to the extraction of bitumen from Athabasca tar sand by a solvent-aqueous-surfactant process. D. F. Gerson, J. E. Zajic, and M. D. Ouchi (Western Ontario, University, London, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 66-79, 24 refs.

A79-40740 # Laboratory simulation of in-situ coal gasification. M. Greenfeld (Alberta Research Council, Fuel Sciences Div., Edmonton, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 80-95.

To provide laboratory support for the Alberta Research Council's underground coal gasification field test program and means for exploring novel operating procedures before taking them into the field, a gasification simulator has been developed. This facility has been designed to reproduce the conditions of a coal seam undergoing gasification, but eliminates peripheral matters (e.g., water incursion) and consequently allows detailed study of reaction kinetics and related aspects (e.g., cavity formation, sweep efficiency and heat losses). In contrast to previous laboratory work, which generally centered on small coal blocks of fixed bed reactors, and which

commonly sought to define limiting conditions that could be correlated with mathematical models, the ARC simulator employs a 1 x 1 x 2 m block which retains most of the essential features of an undisturbed coal seam. (Author)

A79-40741 # Methane production from manure. H. M. Lapp (Manitoba, University, Winnipeg, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 109-119, 14 refs.

Application of anaerobic digestion process to conversion of organic raw material into a useful energy fuel has emerged as a technology that attracts serious attention. The paper discusses the production of methane from animal manure. Attention is given to anaerobic digestion and to technical feasibility of anaerobic digestion for methane production, in terms of manure handling, biological process stability, and biogas handling. The production of methane from animal manure is technically feasible under the management of a livestock enterprise operator. The decision to build an anaerobic digester on a Canadian livestock farm should be based on advantages to be derived from the digester as a component of the total manure handling system. S.D.

A79-40742 # Liquid fuels from carbonates by a microbial system. M. Wayman and M. Whiteley (Toronto, University, Toronto, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 120-132, 14 refs. Research supported by the National Research Council of Canada.

The paper reports on interactions in membrane-separated anaerobic culture of a red photosynthetic bacterium and a colorless nonphotosynthetic sulfate reducing bacterium. Carbonate is the only source of carbon for anaerobic growth in this microbial system. The growth of the separate species is studied, along with the formation and disappearance of sulfide. The harvested microbes are analyzed for protein content. The results suggest an autotrophic source of single cell protein, and also may have some bearing on the early formation of petroleum. S.D.

A79-40743 # Potential of biomass to substitute for petroleum in Canada. C. R. Phillips, D. L. Granatstein, and M. A. Wheatley (Toronto, University, Toronto, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 133-164, 25 refs.

The potential for production of liquid fuels from biomass in Canada is assessed. To this end, the availability and cost of wood wastes, surplus roundwood, bush residues, energy plantation trees, and municipal solid wastes (mostly cellulosic) are examined. Promising thermal, chemical and biochemical conversion processes are discussed. The main competitive options of Canada for long-term liquid fuel supply are shown in tabular form. S.D.

A79-40744 # Potential for biomass utilization in Canada. R. Overend (Department of Energy, Mines and Resources, Renewable Energy Resources Branch, Ottawa, Canada). In: Chemistry for energy; Proceedings of the Symposium, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 165-182, 25 refs.

A biomass technology and resource assessment chart is presented and discussed. The chart consists of five problem areas: resource, harvest and transport, conversion technology, transport, and end use. The present state of knowledge of some of the items in the problem areas are discussed in order to illustrate some of the R&D opportunities in biomass energy. Resources are examined relative to forestry, agriculture, and agro-forestry. Extensive effort is required to improve biomass harvesting and transportation. Conversions technologies and possible developments in biomass energy are considered, along with biomass and the CO₂ problem. Since there is a large biomass resource available in the Canadian forest, biomass will play a vital role complementary to other resources. S.D.

A79-40745 # Material and energy balances in the production of ethanol from wood. M. Wayman, J. H. Lora, and E. Gulbinas (Toronto, University, Toronto, Canada). In: *Chemistry for energy; Proceedings of the Symposium*, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 183-201. 23 refs. Research supported by the National Research Council of Canada and University of Toronto.

Processes for ethanol production from wood are examined in an effort to obtain data on material and energy balances, and possibly on the economics involved. The discussion covers pretreatment of wood, acid hydrolysis, enzyme hydrolysis, fermentation, material and energy balances for acid and enzyme hydrolysis following autohydrolysis and caustic extraction, and the economics of these two processes. Gross energy recoveries (ethanol + lignin) by the two processes are found to be 52.4% and 58.0%, respectively, with net energy recoveries of 36.1% and 42.3%. Economic estimates show a significant advantage in investment and operating costs for the enzyme hydrolysis process. S.D.

A79-40746 # Photochemical aspects of solar energy conversion and storage. J. R. Bolton (Western Ontario, University, London, Canada). In: *Chemistry for energy; Proceedings of the Symposium*, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 202-220. 40 refs.

The paper defines qualitatively and quantitatively the thermodynamic and kinetic limits on the photochemical conversion and storage of solar energy as it is received on the earth's surface. Attention is given to an evaluation of a number of possible reactions, with special emphasis on the generation of solar fuels such as hydrogen from water and the generation of electricity. The photochemical reactions leading to the conversion and storage of solar energy are divided into five types: molecular energy storage reactions, homolytic bond fission reactions, homogeneous redox reactions for generation of solar fuels, photoelectrochemical generation of solar fuels, and photochemical systems designed to generate electricity. It is shown that a reasonable efficiency goal would be about 25-28% for conversion to electricity and about 10-13% for storage as chemical energy. S.D.

A79-40747 # Photoelectrolysis of aqueous solutions to hydrogen - An approach to solar energy storage. F. R. Smith (Newfoundland, Memorial University, St. John's, Canada). In: *Chemistry for energy; Proceedings of the Symposium*, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 221-241. 30 refs.

The paper shows how the advantages of hydrogen storage combined with generation of electricity by solar radiation make the concept of photoelectrolysis of water quite attractive. Photoeffects are observed both at oxygen-evolving anodes and at hydrogen-evolving cathodes, both being useful in practical photoelectrolysis when the incident radiation is ultraviolet. Semiconductor anodes or cathodes are required which do not decompose in the electrolyte and which are electrocatalysts for oxygen or hydrogen production from water. The band gaps of the semiconductors should be reasonably matched to the solar spectrum for high efficiency, and a suitable degree of bending for the bands at the surface is desirable. Materials used as anodes include TiO_2 , various titanates and tantalates, WO_3 and Fe_2O_3 . GaP stands essentially alone as a cathode material. Future prospects for an economic process are discussed. S.D.

A79-40748 # Electrochemically codeposited large-area photoelectrodes for converting sunlight to electrical energy. B. L. Funt, M. Leban, and A. Sherwood (Simon Fraser University, Burnaby, British Columbia, Canada). In: *Chemistry for energy; Proceedings of the Symposium*, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 242-249. 16 refs. Department of Supply and Services Contract No. 8AU77-00433.

Photoelectrochemical cells based on semiconductor photoelectrodes are potential candidates for low-cost large-area conversion devices. The paper describes the construction and performance of a

photoelectrochemical cell of 100 sq cm photoelectrode area obtained by using ten 10 sq cm CdSe photoelectrodes. The theory of the photoelectrochemical cell is described, where the device consists of a CdSe photoelectrode immersed in an aqueous solution which is 1 M in NaOH, Na₂S, and S. Factors involved in producing working devices are discussed along with scale-up considerations. S.D.

A79-40749 # Electrochemical energy storage systems - On the selection of electrolytes for high-energy density storage batteries. E. J. Casey and M. A. Klochko (Defence Research Establishment, Ottawa, Canada). In: *Chemistry for energy; Proceedings of the Symposium*, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 253-302. 155 refs.

The storage-battery field is reviewed with special emphasis on the electrolyte and on an attempt to disclose untried but potentially useful new storage battery systems based on light metals. The discussion covers dry organic and inorganic systems, solid-state electrolytes, and molten-salt electrolyte systems. It is suggested that the slightly solvated low-melting salt systems may become attractive in the future. A recent analysis is summarized of what to expect from an electrical-energy storage system if introduced into small isolated communities in northern Canada. The prospects for the systems considered are discussed. Canadian industrial viewpoints on R&D in electrical energy storage is briefly examined. S.D.

A79-40750 # Fuels cells - Their development and potential. G. Bélanger (Hydro-Québec, Institut de Recherche, Varennes, Canada). In: *Chemistry for energy; Proceedings of the Symposium*, Winnipeg, Manitoba, Canada, June 5-7, 1978. Washington, D.C., American Chemical Society, 1979, p. 303-321. 26 refs.

The fuel cell is an energy conversion device that converts the free energy change of a chemical reaction directly into electrical energy, the conversion occurring by two electrochemical half-cell reactions. This conversion is not subject to the Carnot cycle limitations and is thus theoretically more efficient than a heat-based process. The paper discusses the thermodynamic principles of fuel cells, along with the kinetic aspects of their half-cell reactions. The fundamental problem of electrocatalysis is considered. Different types of fuel cells are described, and the current status of this new power-generating device is outlined. Present R&D efforts are discussed relative to moderate-temperature fuel cells, high-temperature systems, and Canadian contributions. S.D.

A79-40774 * Methanol decomposition bottoming cycle for IC engines. G. Purohit and J. Houseman (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). *Society of Automotive Engineers, Congress and Exposition, Detroit, Mich., Feb. 26-Mar. 2, 1979, Paper 790427*. 19 p. 28 refs.

This paper presents the concept of methanol decomposition using engine exhaust heat, and examines its potential for use in the operation of passenger cars, diesel trucks, and diesel-electric locomotives. Energy economy improvements of 10-20% are calculated over the representative driving cycles without a net loss in power. Some reductions in exhaust emissions are also projected. (Author)

A79-40796 Studies of different energy strategies in terms of their effects on the atmospheric CO₂ concentration. F. Niehaus (International Atomic Energy Agency, Vienna, Austria) and J. Williams (International Institute for Applied Systems Analyses, Laxenburg, Austria). *Journal of Geophysical Research*, vol. 84, June 20, 1979, p. 3123-3129. 12 refs.

A tandem model of the carbon cycle is developed and used to assess the effects of different energy strategies on atmospheric CO₂ concentration. The model correctly simulates the Suess effect, the observed increase in atmospheric CO₂, and the redistribution of bomb-produced C-14. It is shown that the large differences in the future atmospheric CO₂ concentration may be estimated due to

different energy strategies. A maximum level of energy consumption of 30 TW with reliance on nuclear and solar energy leads to a global surface temperature increase of less than 1 C, while a larger ultimate energy consumption and reliance on fossil fuels leads to an increase of 9 C. Implication of these results on decisions for future strategies must be considered. S.D.

A79-40881 Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. Conference sponsored by the Institute of Electrical and Electronics Engineers, New York, Institute of Electrical and Electronics Engineers, Inc., 1978. 1388 p. Members, \$60.; nonmembers, \$80.

These papers deal with recent developments in the design, manufacture, and terrestrial as well as space application of photovoltaic devices. Topics include the future of photovoltaics, tests and demonstrations of photovoltaic power systems, measurements of photovoltaic material properties, radiation and space environmental effects on solar cells, materials and process development for low-cost production of photovoltaic cells, solar cells from 'newer' materials, and space solar-array technology. Other papers consider low-cost R&D for large-scale production, solar cells from alternative materials, silicon material and sheet growth, Cu(x)S/CdS cells, silicon cells for space applications, polycrystalline material and impurity effects in silicon, and In-Sn oxide cells. Space radiation effects on GaAs cells are also discussed, along with device and module technology for low-cost production, silicon MIS cells, solar-concentrator system elements, endurance field tests, tandem cells, and terrestrial applications of photovoltaic power systems. F.G.M.

A79-40882 Trends in photovoltaic development outside the United States. W. Palz (Commission of the European Communities, Directorate General for Research, Science and Education, Brussels, Belgium). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 9-15.

The Photovoltaic Program directed by the Commission of the European Communities, and photovoltaic activities in Belgium, France, Germany (Federal Republic), Italy, the Netherlands, the United Kingdom, India, Iran, Japan, and Mexico are reviewed. Preferred applications for prototype generators are for water pumping and telecommunication systems where at the level of \$2.50 per peak Watt photovoltaic generators can compete with conventional large Diesel generators of several 100 kW or more by 1985. The Commission Program, involving academic and other public institutions and 20 European companies, deals with silicon devices, CdS, CdZnS, CdTe, GaAs cells, linear and central concentrator systems, prototype generators, inverters, and the preliminary design of a 1 MW power plant. V.T.

A79-40883 The Mead 25 kilowatt photovoltaic system. L. L. Bucciarelli, J. D. Cremin, H. A. Fenton, R. F. Hopkinson, E. F. Lyon, W. R. Romaine (MIT, Lexington, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 16-21. Research sponsored by the U.S. Department of Energy.

A 25 peak kW photovoltaic power system, presently the world's largest, has been installed at the University of Nebraska's Agricultural Research Station in Mead, Nebraska. The project goals include the collection of data on solar insolation, photovoltaic (PV) array performance, power conditioning equipment performance, and weather. A comprehensive system of sensors and data logging equipment has been installed for the purpose of collecting these data. The system allows for the automatic transmission of all accumulated data on a daily basis to Lincoln Laboratory in Lexington, Massachusetts, for reduction and analysis. The paper summarizes the data which have been gathered on the array during its initial operating period. (Author)

A79-40884 Status of the photovoltaic concentrator applications experiments. E. L. Burgess (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 35-40. Research supported by the U.S. Department of Energy.

Systems and applications selected for Phase I of the DOE three-phased plan to design, install, operate, and provide cost estimates for a number of different concentrating photovoltaic experiments are discussed. These systems, presented by different companies and ranging from 20 to 500 kW peak electrical output, will be installed in a variety of onsite applications and operated for a period of 1 to 2 years to obtain technical performance and other nontechnical data. Classification of 17 experiments by load type, utility interface, total energy application, optic type, tracking, concentration ratio, and cell type is given. Phase II starts in 1979 and up to 12 months will be required to complete system fabrication and checkout. Thus, the first large-scale photovoltaic concentrator experiments should be operational by mid-1980. Phase III, operation and evaluation should follow for a period of two years. V.T.

A79-40885 Field testing and evaluation of PV module performance. S. E. Forman (MIT, Lexington, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 41-46. Research sponsored by the U.S. Department of Energy.

Between March of 1977 and June of 1978, MIT Lincoln Laboratory in conjunction with the Department of Energy, placed 41.5 kilowatts of photovoltaic modules at various experimental test sites in the United States. The largest of these include a 25 kilowatt array in Mead, Nebraska, which is used for corn irrigation and crop drying and a 15 kilowatt rooftop test bed in Lexington, Massachusetts, which is used to evaluate components of photovoltaic systems prior to field installation. This report summarizes the performance of the photovoltaic modules and describes the physical and electrical changes which have occurred due to weathering and soil accumulation during that time period. To date only nine modules amounting to 130 watts have experienced electrical failures. (Author)

A79-40886 * Procedure for developing experimental designs for accelerated tests for service-life prediction. R. E. Thomas and G. B. Gaines (Battelle Columbus Laboratories, Columbus, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 47-52. 20 refs. Contract No. NAS7-100.

Recommended design procedures to reduce the complete factorial design by retaining information on anticipated important interaction effects, and by generally giving up information on unconditional main effects are discussed. A hypothetical photovoltaic module used in the test design is presented. Judgments were made of the relative importance of various environmental stresses such as UV radiation, abrasion, chemical attack, temperature, mechanical stress, relative humidity and voltage. Consideration is given to a complete factorial design and its graphical representation, elimination of selected test conditions, examination and improvement of an engineering design, and parametric study. The resulting design consists of a mix of conditional main effects and conditional interactions and represents a compromise between engineering and statistical requirements. V.T.

A79-40887 Real-time environmental and performance testing of concentrating photovoltaic arrays. J. L. Watkins and D. A. Pritchard (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 53-59. Research supported by the U.S. Department of Energy.

This paper describes the Photovoltaic Advanced Systems Test Facility. Several of the concentrating photovoltaic arrays tested are

described along with their typical performance. An example of accelerated aging is given in which a concentrator module is exposed to severe temperature and humidity cycling, and the performance degradation is determined. Finally, plans for future testing are given, including an expansion of the facility. (Author)

A79-40889 Measurement of bandgap narrowing and diffusion length in heavily doped silicon. J. van Meerbergen, J. Nijs, R. Mertens, and R. Van Overstraeten (Leuven, Katholieke Universiteit, Heverlee, Belgium). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 66-69. 7 refs. Research supported by the Nationale Fonds voor Wetenschappelijk Onderzoek; Commission of the European Communities Grant No. 153-77-9-ESB.

A new method for simultaneous measurement of bandgap narrowing, diffusion length and minority carrier lifetime in a heavily doped n(+) substrate is proposed. The method uses planar test pattern at the frontside of the substrate to determine the hole minority carrier current injected from a p type emitter and diodes at the rear side to measure diffusion lengths and minority carrier lifetimes. Results of measured values of bandgap narrowing, diffusion length, diffusion constant and lifetime versus impurity concentration are shown for n type material. (Author)

A79-40890 * Forward-bias capacitance and current measurements for determining lifetimes and band narrowing in p-n junction solar cells. A. Neugroschel, P. J. Chen, S. C. Pao, and F. A. Lindholm (Florida, University, Gainesville, Fla.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 70-75. 26 refs. Grant No. NSG-3018; Contract No. E(40-1)5134.

A new method is described and illustrated for determining the minority-carrier diffusion length and lifetime in the base region of p-n junction solar cells. The method requires only capacitance measurements at the device terminals and its accuracy is estimated to be + or - 5%. It is applied to a set of silicon p-n junction devices and the values of the diffusion lengths agree with those obtained using the current response to X-ray excitation but disagree with those obtained by the OCVD method. The reasons for the relative inaccuracy of OCVD applied to silicon devices are discussed. The capacitance method includes corrections for a two-dimensional fringing effects which occur in small area devices. For a device having highly-doped base region and surface (emitter) layer, the method can be extended to enable the determination of material properties of the degenerately doped surface layer. These material properties include the phenomenological emitter lifetime and a measure of the energy band-gap narrowing in the emitter. An alternate method for determining the energy band-gap narrowing from temperature dependence of emitter current is discussed and demonstrated. (Author)

A79-40891 Measurement of free carrier lifetime in an illuminated solar cell from capacitance measurements. S. Y. Harmon and C. E. Backus (Arizona State University, Tempe, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 76-82. 30 refs. U.S. Department of Energy Contract No. 05-6037.

The small signal resistive and capacitive components of the ac impedance of an illuminated silicon solar cell were measured using a lock-in amplifier as a phase sensitive voltmeter. Based on the assumption of a dominant diffusion capacitive component of total device capacitance, the cell impedance data were used to compute the cell's device carrier lifetime as a function of incident energy. These results showed the device carrier lifetime decreased steadily with increasing incident energy. However, this interpretation ignores the effects of series resistance and transition region impedance on the data. (Author)

A79-40892 Contactless measurement of lifetime by free carrier infrared absorption. R. J. Schwartz and J. L. Gray (Purdue University, West Lafayette, Ind.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 83-88. 5 refs. U.S. Department of Energy Contract No. 05-4411.

A technique is described which allows the measurement of high injection free carrier lifetime without the necessity of making electrical contact to the wafer. The technique utilizes the free carrier absorption of an infrared beam to monitor the carrier concentration as a function of time after the application of an exciting light pulse. The theory of the experiment is presented along with a description of the apparatus. A typical experimental result is compared with a theoretical prediction. The technique is found to be particularly useful in the monitoring of high injection lifetime in interdigitated back contact solar cells. (Author)

A79-40893 Minority carrier diffusion length from spectral response measurements. R. O. Bell and G. M. Freedman (Mobil Tyco Solar Energy Corp., Waltham, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 89-94. 12 refs.

Measurement of the spectral response behavior of a photocell can be used to determine the minority carrier diffusion length in the base. Results on as-grown silicon material are obtained by using a Schottky surface barrier and on processed material by using finished solar cells. In addition, by appropriate modeling and curve fitting other cell and material parameters can be determined. These include the minority carrier diffusion length in the surface, junction depth and surface recombination velocity. (Author)

A79-40894 Diffusion length inhomogeneities in silicon solar cells. T. L. Chu and E. D. Stokes (Southern Methodist University, Dallas, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 95-99. 8 refs. Contract No. EY-76-C-03-1285.

Minority carrier diffusion length in the base region of a solar cell is the most important factor affecting its long wavelength performance. Although the diffusion length in solar cells has been measured by several techniques, very little attention has been directed to diffusion length inhomogeneities. In this work, a high resolution technique utilizing short-circuit current collection has been used to measure the diffusion length profile in single crystalline silicon solar cells with or without light-bias. The short-circuit current profile generated by illuminating localized areas of solar cells with radiation of known energy and power density was also measured. A majority of the solar cells examined so far exhibit inhomogeneities in diffusion length and similar variations in short-circuit current density under long wavelength or white illumination. (Author)

A79-40895 # Solar cell experiments on the NTS-2 satellite. D. H. Walker, R. L. Statler, and R. J. Lambert (U.S. Navy, Naval Research Laboratory, Washington, D.C.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 100-106. 22 refs. Navy-USAF-supported research.

There were fifteen solar cell experiments aboard the NTS-2 satellite launched 23 June 1977. The solar cell experiments consist of fifteen separate experiments, each containing an array of five 2 x 2 cm solar cells. Among the experiments are included GaAlAs/GaAs heteroface structure cells, Comsat high efficiency black cells, vertical junction cells, adhesiveless coverslides and coverslides without antireflective coatings and/or ultraviolet reflection filters. The average value of Isc measured in space on the first day of exposure agreed with solar simulator values to 1.41 + or - 0.99 percent. The agreement between Voc in space with solar simulator values was 1.24

+ or - 1.08 percent. The trapped radiation flux of electrons and protons in NTS-2's 12-hour, 63-degree orbit is equivalent to 2×10 to the 14th power 1-MeV electrons/sq cm per year. Over the design life of three years, the main solar paddles consisting of Spectrolab Helios cells covered with 0.025 cm ceria microsheet will lose 26 percent in maximum power. Results of the first 223 days in orbit are presented. (Author)

A79-40896 **Space environment damage to solar cell cover-slide assemblies.** A. Meulenberg, Jr. (COMSAT Laboratories, Clarksburg, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 107-115. Research sponsored by the International Telecommunications Satellite Organization, Communications Satellite Corp., and Optical Coating Laboratory.

A series of experiments was undertaken to determine the extent and nature of ultraviolet (UV) damage to the new violet and nonreflective type solar cell assemblies. The experiments consisted of three types of tests on fused silica coverslides with 0.35- and 0.30-micron filters and without cutoff filters, as well as on ceria doped microsheet coverslides. The tests measured short-circuit current of and reflectance from covered cells and reflectance plus transmission of coverslide-adhesive-fused silica 'sandwiches'. Results extrapolated to 5 yr in space indicate a UV degradation in Isc of about 5 percent for Ta2O5 coated nonreflective cells with 0.35-micron UV filters; the nonreflective cells with 0.30-micron filters would degrade by about 6.7 percent, and those without filters by more than 8.5 percent. Infrared degradation prior to UV irradiation adds an additional loss of up to 1 percent. (Author)

A79-40897 **The effect of protons electrons and photons on the performance of some new types of high efficiency solar cells.** A. A. Dollery, M. W. Walkden, and R. L. Crabb (Royal Aircraft Establishment, Farnborough, Hants., England; ESA, Noordwijk, Netherlands). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 116-121.

The paper describes the experiment and gives the results of an investigation into the performance degradation of a range of the latest types of high efficiency solar cells, when subjected to proton, electron and photon irradiation. The experiment was confined to energies of 1 MeV and 10 MeV for electrons and protons respectively and covered the fluence range up to 10 to the 15th power e/sq cm and 10 to the 12th power p/sq cm. Photon radiation was 1 AMO solar constant for 24 h. The cells comprised 7 different types from US and European manufacture. Damage ratios at this energy are given, together with details of the behavior of each type of cell. (Author)

A79-40898 * # **Ultraviolet irradiation at elevated temperatures and thermal cycling in vacuum of FEP-A covered silicon solar cells.** J. D. Broder and S. J. Marsik (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 122-126. 9 refs.

Silicon solar cells covered with FEP-A were irradiated in vacuum with ultraviolet light and then subjected to thermal cycling. These accelerated laboratory conditions are believed to be equivalent to those experienced by FEP-A covered cells on the ATS-6 spacecraft and the results indicate a probable mechanism for the faster degradation of the FEP-A covered cells. Heat-bonded FEP-A covers apparently embrittle when exposed to four months of space UV radiation at elevated temperatures, and crack when subjected to thermal cycling during the eclipse period. Low energy proton radiation can then penetrate to the junction of the cell causing degradation of the open circuit voltage and maximum power to occur. An alternate method of application of FEP-A, such as with adhesives, may prevent such cracking. V.T.

A79-40899 **Flash X-ray tests of solar cells.** M. T. Gates (Hughes Aircraft Co., El Segundo, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 127-130.

Flash X-ray tests were conducted using three silicon solar cell types: one conventional design and two advanced designs. At high injection levels the two advanced design cells with back surface fields developed more voltage than the conventional cell. Unlike the advanced cells, the conventional cell exhibited voltage saturation at moderate injection levels and showed an initial voltage loss at high X-ray dosages. Charge storage times for the two advanced cell designs were comparable and were greater than the conventional cell storage time. (Author)

A79-40900 **Growth and characteristics of polysilicon layers achieved by the ribbon-against-drop /RAD/ pulling process.** C. Belouet, J. Hervu, R. Martres, N. T. Phuoc, and M. Pertus (Laboratoires d'Electronique et de Physique Appliquée, Limeil-Brevannes, Val-de-Marne, France). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 131-136. 8 refs. Research supported by the Commission of the European Communities.

The recent achievements in the growth of polycrystalline silicon layers by the ribbon against-drop (RAD) pulling process for solar cell purposes are presented. Layers about 100 micron thick were deposited on 2cm wide ribbon-like carbon substrates over lengths of tens of centimeters at pulling rates up to 6cm/min. The factors which control the size of the fibrous-like and columnar grains and the role of the carbon substrate in determining the temperature profile in the silicon layer are examined. The structural and electrical characteristics of the as-grown layers have been investigated and the results are described. Solar cells have been fabricated with n(+)/p diffused homojunctions and AM1 conversion efficiencies of 7 percent have been realized whereas efficiencies up to 9 percent were obtained on layers separated from their substrate. (Author)

A79-40901 **Directional solidification of crack-free silicon ingots by heat exchanger method.** C. P. Khattak and F. Schmid (Crystal Systems, Inc., Salem, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 137-141. 17 refs. Research sponsored by the U.S. Department of Energy.

Silicon crystals are being grown for photovoltaic applications by a directional solidification casting technique. One of the major problems in casting silicon in silica crucibles is the cracking of the ingot during the cooling cycle. Graded crucibles have been developed which delaminate thereby eliminating cracking of the cast silicon. Boules as large as 3 1/2 kg have been solidified with a high degree of crystallinity. The origin of silicon carbide formed at high temperatures in vacuum has been attributed to the use of silica crucibles in contact with graphite retainers. Solar cells fabricated out of the cast silicon have shown conversion efficiencies of up to 14% (AM1). (Author)

A79-40902 * **Effect of multiblade slurry saw induced damage on silicon solar cells.** T. Daud, J. K. Liu, G. A. Pollock, and K. M. Koliwad (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 142-146. Contract No. NAS7-100.

A correlation between the optimum etch loss and the depth of damage is established using wafers produced by the Multiblade Slurry (MBS) and the Internal Diameter (ID) saws. The observations are based on the measurement of the performance of solar cells fabricated on these wafers. Sample preparation and test results are described and the following conclusions are made: (1) the amount of

silicon removal necessary for optimum solar cell performance coincides with the depth of saw-induced damage; (2) optimization of cell performance is not affected by the method of silicon removal; (3) sawing conditions should be optimized to minimize the extent of saw-induced damage; (4) the MBS saw is found to induce damage to a lesser extent; (5) since the extent of damage in MBS-sawn wafers is in the limit of etch loss required in texture etching, it is possible to achieve optimum improvement in cell performance by merely texture etching the surface of as-sawn wafers. V.T.

A79-40903 Analysis of ID saw slicing of silicon for low cost solar cells. H. Yoo, R. G. Schwartz, and P. A. Iles (Optical Coating Laboratory, Inc., City of Industry, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 147-151.

A brief description of three silicon slicing methods using Multiblade Slurry (MBS), Internal Diameter (ID), and Multiwire Slurry (MWS) saws is given. Attention is given to the ID method because it is considered the baseline method used by most of the silicon industry. Mechanical wafer parameters, such as thickness variations, taper, bow and roughness are considerably better for wafers sliced with the ID saw and MWS saw than for those with the MBS saw. Wafers sawn with the ID saw showed slightly better parameters than those with the MWS saw. Cost assessment also indicated that the ID saw slicing is more favorable and its capability of automation adds advantage over the other two methods. Further reduction in wafering cost can be expected by increasing machine productivity and decreasing kerf width by ganging blades, programmed cutting, use of thinner blades and a rotating crystal system. V.T.

A79-40904 * A high volume cost efficient production macrostructuring process. S. R. Chitre (Sensor Technology, Inc., Chatsworth, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 152-154. Contract No. JPL-954605.

The paper presents an experimentally developed surface macrostructuring process suitable for high volume production of silicon solar cells. The process lends itself easily to automation for high throughput to meet low-cost solar array goals. The tetrahedron structure observed is 0.5 - 12 micron high. The surface has minimal pitting with virtually no or very few undeveloped areas across the surface. This process has been developed for (100) oriented as cut silicon. Chemi-etched, hydrophobic and lapped surfaces were successfully texturized. A cost analysis as per Samics is presented. (Author)

A79-40905 High efficiency, high density terrestrial solar panels. M. Wihl and J. Wohlgemuth (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 155-159.

Technology to fabricate large area, square, rectangular, and nearly rectangular cells with 14 to 15 percent conversion efficiencies at 1 kW/sq m at 28 C has been developed and a description of two types of high density panels is given. The first type uses 5 cm x 5 cm cells and give a packing density of 90%. The second type uses nearly square 6.3 cm x 6.3 cm cells with a packing density of 83%. Panels have been fabricated exhibiting 13% total panel area efficiency. Economic evaluations are made for the different type panels using today's technology and projecting costs for future developments. It is concluded that the high density technology sets the stage for future developments in silicon fabrication. V.T.

A79-40906 * Development of a shingle-type solar cell module. N. F. Shepard, Jr. (General Electric Co., Space Div., Philadelphia, Pa.) and L. E. Sanchez (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8,

1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 160-164. Research sponsored by the U.S. Department of Energy.

The development of a solar cell module, which is suitable for use in place of shingles on the sloping roofs of residential or commercial buildings, is reported. The design consists of nineteen series-connected 53 mm diameter solar cells arranged in a closely packed hexagon configuration. The shingle solar cell module consists of two basic functional parts: an exposed rigid portion which contains the solar cell assembly, and a semi-flexible portion which is overlapped by the higher courses of the roof installation. Consideration is given to the semi-flexible substrate configuration and solar cell and module-to-module interconnectors. The results of an electrical performance analysis are given and it is noted that high specific power output can be attributed to the efficient packing of the circular cells within the hexagon shape. The shingle should function for at least 15 years, with a specific power output of 98 W/sq w. V.T.

A79-40907 The properties of homoepitaxial InP films prepared by the MO-CVD process for the fabrication of heterojunction solar cells. H. M. Manasevit, K. L. Hess, P. D. Dapkus, R. P. Ruth, J. J. Yang, A. G. Campbell, R. E. Johnson, L. A. Moudy (Rockwell International Electronics Research Center, Anaheim, Calif.), R. H. Bube, and L. B. Fábick (Stanford University, Stanford, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 165-173. 27 refs. Contract No. EY-76-C-04-3727.

A79-40908 Cuprous oxide photovoltaic cells. D. Trivich, E. Y. Wang, R. J. Komp, and A. S. Kakar (Wayne State University, Detroit, Mich.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 174-179. 9 refs. Research supported by the U.S. Department of Energy, International Copper Research Association, and NSF.

Cuprous oxide, with a band gap of 2.0 eV, is an attractive material for solar cells because of low cost and great availability. The current conversion efficiency is 1%, but theoretical estimates are greater than 13%. For various Schottky barriers, e.g., Al/Cu₂O, it is proposed that the open-circuit voltage is limited by chemical conversion of the junctions to Cu/Cu₂O junctions, and the model is supported by Auger and ESCA results. It is proposed to avoid the reaction by use of an oxide interlayer as in Al/Al₂O₃/Cu₂O, which also gives an MIS structure, but only minimal success has yet been achieved with the methods tried. Sb₂O₃ and SiO(x) layers were explored. Another approach could be to use oxide heterojunctions on Cu₂O. Several were explored and ZnO/Cu₂O was best. In and Cd are effective dopants for Cu₂O. With samples annealed at 500 C, diffusion lengths of about 4 microns were measured by an SPV method. The spectral sensitivity of Cu/Cu₂O cells has a threshold at 630 nm and a maximum at 500 nm. (Author)

A79-40909 The photovoltaic properties of thin copper oxide films. V. F. Drobny and D. L. Pulfrey (British Columbia, University, Vancouver, Canada). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 180-183. 14 refs.

Thin copper oxide films have been prepared by reactive sputtering in argon/oxygen atmospheres. The composition of the films depends on the oxygen partial pressure in the discharge. Films of a given composition show definite and distinct optical and resistive properties. These properties are evaluated from the standpoint of photovoltaic applications. Preliminary data on the performance of Cu₂O/Si heterojunction solar cells is presented. (Author)

A79-40910 The performance of copper-ternary based thin-film solar cells. L. L. Kazmerski, P. J. Ireland (Solar Energy Research Institute, Golden, Colo.), F. R. White, and R. B. Cooper (Maine, University, Orono, Me.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 184-189. 12 refs.

The performance of the Cu-ternary thin-film photovoltaic device, with some emphasis on the CdS/CuInSe₂ solar cell, is examined. A model for this heterostructure is presented and correlated with reported device performances. Attainable efficiencies based upon obtainable materials' properties and producible electrical, optical, and structural characteristics are predicted. Temperature dependences of V_{sub} OC and J_{sub} 0 are used to determine electron affinity difference and interface recombination velocity, respectively. Dark capacitance-voltage data are presented for the CdS/CuInSe₂ device and diffusion voltages are reported. Heterojunction band diagrams are given for present and optimized device situations.

(Author)

A79-40911 Investigation of thin film cadmium sulfide/mixed copper ternary heterojunction photovoltaic cells. J. J. Loferski, J. Shewchun, B. Roessler, R. Beaulieu, J. Piekoszewski (Brown University, Providence, R.I.), M. Gorska, and G. Chapman. In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 190-194. 5 refs. Contract No. EG-77-C-03-1579.

A79-40912 Spray deposited Cd(1-x)Zn(x)/S films for low cost solar cells. O. P. Agnihotri and B. K. Gupta (Indian Institute of Technology, New Delhi, India). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 195-199. 15 refs.

Cd(1-x)Zn(x)S films suitable for use in solar cells were produced by a low cost chemical spray process and the process of film preparation is described giving attention to spectral transmission and absorption coefficient, film structure and resistivity, current and voltage characteristics in dark and under different illuminations, spectral response of photocurrent, and majority carrier life time. The transition from wurtzite structure typical for CdS to the characteristic ZnS Zinc-blend form took place abruptly at 80 mole % ZnS concentration. The bandgap has a nearly linear variation with composition except at x = 1 where the material is amorphous and has a gap (about 3.2 eV) which is less than the polycrystalline ZnS case. The ratio of light to dark current is maximum at x = 0 and for x = 0.2 to 0.4 ranges between 10 to the 4th power to 10 to the 2nd power.

V.T.

A79-40913 * Ultra-low-mass flexible planar solar arrays using 50-micron-thick solar cells. E. N. Costogoe (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and G. Rayl (General Electric Co., Philadelphia, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 200-207. Contract No. NAS7-100.

A conceptual design study has been completed which has shown the feasibility of ultra-low-mass planar solar arrays with specific power of 200 watts/kilogram. The beginning of life (BOL) power output of the array designs would be 10 kW at 1 astronomical unit (AU) and a 55C deg operating temperature. Two designs were studied: a retractable rollout design and a non-retractable fold-out. The designs employed a flexible low-mass blanket and low-mass structures. The blanket utilized 2 x 2 cm high-efficiency (13.5% at 28C deg AMO), ultra-thin (50 micron), silicon solar cells protected by thin (75 micron) plastic encapsulants. The structural design utilized the 'V'-stiffened approach which allows a lower mass boom to be

used. In conjunction with the conceptual design, modules using the thin cells and plastic encapsulant were designed and fabricated.

(Author)

A79-40914 Family of solar array design options. R. V. Elms, Jr. (Lockheed Missiles and Space Co., Inc., Sunnyvale, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 208-214. 8 refs.

The characteristics of a family of large area solar array design options are presented. The designs are applicable to a range of space missions and which maximize the use of a common array design technology. The array family is made up of combinations of planar flat fold array blankets and planar flat fold sun concentrating reflectors to satisfy specific array requirements for a variety of space missions. The design of the array elements allows the use of ultra-lightweight array blanket technology to meet high array specific power requirements or the use of heavier technology to provide a minimum cost per watt design. The basic array technology elements are characterized along with their performance. The alternate design details for these basic elements are discussed to show how they accommodate the different space missions of interest. The details of a solar array configuration for each of a set of typical space missions are described with the reasons for selection of specific alternate design details.

(Author)

A79-40915 Latest developments in solar array technology at AEG-Telefunken. J. Koch and I. Lydorf (Telefunken AG, Wedel, West Germany). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 215-220. 5 refs. Research supported by the Bundesministerium für Forschung und Technologie.

AEG-Telefunken developments for future solar generators are described in detail. A carbon fibre reinforced substrate was developed for obtaining a solar cell blanket with good mechanical data, a low coefficient of thermal expansion, and a conductive rear side. In order to avoid charging effects in the blanket, a method allowing the application of a conductive layer on the rear side of a nonconductive substrate was developed. For the case of defects in a solar generator a repair technique was developed and proved in the space projects IUE, OTS, and GEOS. A new low outgassing silicone adhesive was also developed and as an alternative to the existing resistance welding technique a laser welding technique was investigated for the interconnection of solar cells.

V.T.

A79-40916 The ESA lightweight hybrid solar array. C. J. H. Williams and I. V. Franklin (British Aerospace, Dynamics Group, Bristol, England). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 226-231. Research supported by the European Space Agency.

The design and development of a low cost lightweight Hybrid Solar Array (LHSA) for satellites requiring nominal power in transfer orbit and full operational power in geostationary orbit are presented. Consideration is given to the LHSA configurations and operations, and such LHSA subassemblies as a yoke, a rigid primary panel, a flexible secondary panel stowage, a secondary deployment mechanism, flexible secondary panels, and solar cells are described. Attention is given to the LHSA development program conducted for ESA and including the subassembly and design verification unit tests. Apart from the low cost, and lightness of the LHSA, a critically important feature is the small stowed volume which may render the LHSA the only choice for certain missions.

V.T.

A79-40917 The TDRSS solar array. H. S. Rauschenbach, F. G. Kelly, and M. D. Cannady (TRW Defense and Space Systems Group, Redondo Beach, Calif.). In: Photovoltaic Specialists Confer-

ence, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 232-237. 6 refs.

An advanced lightweight, oriented solar cell array has been designed to provide over 2 kW output after 10 years in geosynchronous orbit at a specific power of 25.5 W/kg and a specific mass of 2.92 kg/sq m. The array substrate, fabricated from aluminum honeycomb core and Kapton facesheets, is supported by graphite fiber reinforced plastic beams and is treated against electrostatic charging effects. Hybrid back surface reflector type solar cells, having 11.4% efficiency, are protected by ceria doped coverglasses. Bypass diodes protect some cells from excessive reverse bias. Thermophysical properties and electrical characteristics of unirradiated and irradiated cells and covers are reported. Continuing vacuum temperature cycling life tests showed no degradation after 500 cycles.

(Author)

A79-40918 Status and future development of photovoltaic research in the Federal Republic of Germany. R. Koepke (Kernforschungsanlage Jülich GmbH, Jülich, West Germany). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 238-240. 9 refs.

A review of different activities on photovoltaic research in the Federal Republic of Germany, including the projects that will start in the near future, is presented. Attention is given to polycrystalline silicon cells and generators. An eight-year program has been started in 1977 with the main goal to make a complete production line for terrestrial silicon solar cells and generators. A comprehensive program to study the material properties of amorphous silicon solar cells has been established while the development of CdS-solar cells is considered to be necessary as an alternative to concentrated effort on silicon solar cells. In addition to these priority activities there are some projects in which alternative solar cells materials, such as CdSe-MIS-thin film solar cells, monocrystalline CdTe solar cells, polycrystalline n- and p-MIS-silicon cells are investigated. V.T.

A79-40919 * A candidate low-cost processing sequence for terrestrial silicon solar cell panel. D. B. Bickler, B. D. Gallagher, and L. E. Sanchez (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 241-245. 5 refs. Research sponsored by the U.S. Department of Energy.

Manufacturing sequence for silicon solar cells using Czochralsky crystal growing techniques in order to produce at a rate of 20 MW per year on a 24-hour per day basis is discussed. Cost analysis of the manufacturing is presented and consideration is given to the following processing decision categories of the manufacturing of an unencapsulated solar cell from a silicon wafer: (1) treatment of the optical surface; (2) formation of the junction(s); and (3) metallization of electrical collectors. The manufacturing of encapsulated solar modules from solar cells, using two glass plates, a low iron front surface, and a standard float glass back plate, is described. Totalling the three major activities of wafer making, cell manufacturing, and module fabrication, the resulting contribution to module price will be 1.945 \$/watt. V.T.

A79-40920 * Silicon solar cells, a manufacturing cost analysis. L. A. Grenon and M. G. Coleman (Motorola, Inc., Phoenix, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 246-251. Research supported by the U.S. Department of Energy; Contract No. JPL-954363.

A detailed cost analysis of solar cell module manufacturing, utilizing process sequences incorporating near-term technology, has been performed. The entire structuring of a factory to manufacture solar cell modules, starting from supplied polycrystalline silicon and other raw materials, was specified. This analysis then formed the

basis for a sensitivity analysis of the major cost factors. The results of the cost and sensitivity analyses are presented here. (Author)

A79-40921 A 1982 low cost photovoltaic module factory study. B. G. Carbajal (Texas Instruments, Inc., Dallas, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 252-256. Research sponsored by the U.S. Department of Energy.

An analysis of a 1982 Solar Photovoltaic Factory was made to determine the feasibility of achieving a \$2.00 per watt selling price in 1982. The study concluded that an aggressive goal oriented program could achieve the target price with a production rate in the range of 25-30 MW per year. (Author)

A79-40922 Low cost manufacturing of monocrystalline silicon solar cells - A review of technological solutions. Y. Salles, D. Digue, and H. Lauvray (La Radiotechnique Compelec, Caen, France). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 257-261. 9 refs. Research supported by the Délégation Générale à la Recherche Scientifique et Technique and Commission of the European Communities.

Techniques for achieving short-term cost reduction in the manufacturing of single-crystal silicon solar cells are outlined. CZ ingot growth conditions are described. Three wafering methods are compared: ID slicing, multiblade sawing, and multiwire sawing. Solar cell processing is emphasized and optimum manufacturing conditions are discussed. Typical characteristics of large-diameter solar cells made by such simplified processes are presented. B.J.

A79-40923 Silicon solar cell arrays - Technical status, terrestrial applications, and future developments for low cost production. R. Buhs (Telefunken AG, Wedel, West Germany). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 262-267.

The current status of terrestrial solar generators is characterized by the use of 5 x 5 sq cm large solar cells of monocrystalline base material, interconnected by welding, and encapsulated between glass. The first solar generator modules which are composed of 25 sq cm and 100 sq cm large polycrystalline solar cells with efficiencies around 10% have been manufactured and are being tested. Among the various terrestrial projects some are considered which represent the most promising applications in the near future. To improve the economy of photovoltaics AEG-Telefunken is performing an eight-year-program. The program has three phases. It covers the development of both low-cost solar generators and economical power conditioning systems. At the end of Phase III a cost goal of less than 5 DM/Watt (peak) will be realized. (Author)

A79-40924 High efficiency, low cost processes for 3 in. diameter silicon solar cells. J. Kukulka, J. Shewchun, A. Kazandjian, and D. Burk (McMaster University, Hamilton; Solar Power Developments, Ltd., Burlington, Ontario, Canada). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 268-270.

By combining low cost processes with techniques for obtaining high efficiency, large diameter silicon solar cells have been produced for terrestrial use which satisfy the often conflicting requirements of a relatively inexpensive yet high performance solar cell. Using spin-on diffusion sources with textured surfaces, we have been able to produce 15% efficient (AM1) solar cells. The processing conditions to achieve such performance will be described in detail. (Author)

A79-40925 * Evaluation of options for process sequences. M. Wolf, H. M. Goldman (Pennsylvania, University, Philadelphia, Pa.), and A. C. Lawson (California Institute of Technology, Jet

Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 271-280. 24 refs. Research supported by the U.S. Department of Energy; Contract No. JPL-954796.

A methodology is being developed to ease the comparative evaluation of competing options in the process sequence for the manufacture of photovoltaic solar energy utilization systems. This evaluation will largely involve process economic analyses but will place equal emphasis on other characteristics, including energy consumption and environmental effects of the process options. Early analyses have been performed for the energy consumption in the arc furnace reduction of SiO₂, for the costs and energy consumption in CZ crystal pulling and various slicing processes, and for the total energy consumption of process sequence through the completed module. B.J.

A79-40926 Recent investigations of metal oxide/CdTe heterojunction solar cells. A. L. Fahrenbruch, J. Aranovich, F. Courreges, T. Chynoweth, and R. H. Bube (Stanford University, Stanford, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 281-287. 13 refs. Research supported by the U.S. Department of Energy.

Investigations of the properties of ZnO and ITO films both on glass and as components of single crystal p-CdTe based heterojunction solar cells are described. It is shown that ZnO films deposited by RF sputtering or spray pyrolysis can be brought within the desired conductivity range for solar cell performance. First generation n-ZnO/p-CdTe solar cells show high value of short-circuit current (19 mA/sq cm) and solar efficiency (4.6% at AM2 simulation). Heterojunctions of n-ITO/p-CdTe prepared by RF sputtering give an open-circuit voltage of 0.82 V, a short-circuit current of 14.5 mA/sq cm, and a solar efficiency of 8%, but properties are very sensitive to preparation variables. B.J.

A79-40927 Zn3P2 - A promising photovoltaic material. A. Catalano, V. Dalal, W. E. Devaney, E. A. Fagen, R. B. Hall, J. V. Masi, J. D. Meakin, G. Warfield, N. Convers Wyeth and A. M. Barnett (Delaware University, Newark, Del.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 288-293. 12 refs. Contract No. EX-76-C-01-2460.

A review of the limited available literature, led to the selection of zinc phosphide, Zn3P2, as a promising material for photovoltaic devices. The important electrical, optical and device parameters have now been experimentally determined. They are: (1) a direct optical band gap of about 1.5 eV, (2) a minority carrier diffusion length of not less than 6 microns, and (3) metal-semiconductor barrier heights in the range of 0.7 to 0.8 eV. (Author)

A79-40928 Eutectic and cellular solar cells. C. H. Li (New York, State University, Stony Brook, N.Y.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 294-297. 17 refs.

Two new types of solar cells with unique designs, manufacturing processes, and performance characteristics are proposed. These types may yield 18% efficient, stable and radiation-resistant silicon cells at greatly reduced cost. The new cells are designed according to the vertical multi-junction principle, but with optimum micron sizes and spacings. The parallel and columnar silicon (or GaAs) rods or sheets are embedded in a metal matrix, which forms the common, one-side low resistance contact and reinforces the brittle silicon (or GaAs) rods or sheets, thereby reducing the wafer thickness required. The cell manufacture is simple, high-yielding, and low in cost. Promising results have been obtained on this approach. (Author)

A79-40934 High-temperature contacts for silicon solar cells. T. J. Faith (RCA, Astro-Electronics Div., Princeton, N.J.) and P. A. Iles (Optical Coating Laboratory, Inc., City of Industry, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 321-326. 17 refs.

Destructive isothermal vacuum anneals have determined high-temperature degradation rates for silicon solar cells with several different front-end metallizations. For most metallizations, including Ti-Ag and Al, degradation occurred principally through shunting. Conventional junction cells with standard Ti-Ag contacts failed after about 600 sec at 550 C. Elimination of the Ag overlap at the contact edge resulted in an increase of failure time to 9000 sec. Shallow junction devices with Ti-Ag contacts failed about 30 times faster than corresponding devices with a conventional junction depth. Auger composition profiles show that Ti-S compound formation is responsible for saturation-current degradation and suggest that Ti, Ag, and Si all contribute to shunting. B.J.

A79-40935 The alpha factor - Controlling solar cell absorptance. P. A. Iles and S. Khemthong (Optical Coating Laboratory, Inc., City of Industry, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 327-332. 7 refs.

Advanced solar cells designed for increased output in space, especially cells with textured surfaces, have been shown to have high values of solar absorptance. Previous solar-absorptance-values were generally in the range 0.80 to 0.84, but values above 0.85, often as high as 0.94 were reported. These increased solar-absorptance-values can cause cell arrays to run hotter in space, with consequent decrease in cell output. This paper describes the relation between in-orbit power and solar-absorptance, how solar-absorptance depends on the cell and cover properties, and which processing adjustments can be effective for different cell designs. (Author)

A79-40936 * Advances in the Dow Corning process for solar-grade silicon. L. P. Hunt, V. D. Dosaj, J. R. McCormick, and A. W. Rauchholz (Dow Corning Corp., Hemlock, Mich.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 333-338. 9 refs. Research sponsored by the U.S. Department of Energy; Contract No. JPL-954559.

The Dow Corning process consists of the carbothermic reduction of silica to produce silicon that is then purified by unidirectional solidification. The process has produced silicon of semiconductor quality with respect to all elements except boron and phosphorus at about 10 ppma and aluminum at 0.1 ppma. Solar cells produced from this silicon gave AMO conversion efficiencies of 11%. A process cost analysis is presented. B.J.

A79-40939 * Multiple silicon ribbon growth by EFG. B. H. Mackintosh, T. Surek, J. P. Kalejs, E. M. Sachs, S. Nagy, and F. V. Wald (Mobil Tyco Solar Energy Corp., Waltham, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 350-357. 15 refs. Research supported by the U.S. Department of Energy; Contract No. JPL-954355.

The background and progress to date of EFG ribbon growth for solar cell applications are briefly reviewed. The design and operation of a multiple ribbon-per-operator manufacturing system are then described. Results are presented of cost studies of this system at three stages of development. In the latter stage, believed to be attainable by 1986, conversion costs for polycrystalline silicon into wafers are attained which are consistent with manufacture of photovoltaic systems at \$0.50 per peak watt. Principal technological problems in the ribbon growth process are discussed. (Author)

A79-40940 * **Computer modeling of dendritic web growth processes and characterization of the material.** R. G. Seidensticker, R. E. Kothmann, J. P. McHugh, C. S. Duncan, R. H. Hopkins, P. D. Blais, J. R. Davis, and A. Rohatgi (Westinghouse Electric Corp., Pittsburgh, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 358-362. 6 refs. Research sponsored by the U.S. Department of Energy and NASA.

High area throughput rate will be required for the economical production of silicon dendritic web for solar cells. Web width depends largely on the temperature distribution on the melt surface while growth speed is controlled by the dissipation of the latent heat of fusion. Thermal models were developed to investigate each of these aspects, and were used to engineer the design of laboratory equipment capable of producing crystals over 4 cm wide; growth speeds up to 10 cm/min were achieved. The web crystals were characterized by resistivity, lifetime and etch pit density data as well as by detailed solar cell I-V data. Solar cells ranged in efficiency from about 10 to 14.5% (AM-1) depending on growth conditions. Cells with lower efficiency displayed lowered bulk lifetime believed to be due to surface contamination. (Author)

A79-40949 **Achievement of 9.15% efficiency in thin film CdS/Cu₂S solar cells.** A. M. Barnett, J. A. Bragagnolo, R. B. Hall, J. E. Phillips, and J. D. Meakin (Delaware University, Newark, Del.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 419, 420. 6 refs. Contract No. EG-77-C-03-1576.

Thin film photovoltaic solar cells based on cadmium sulfide/copper sulfide have been developed which have energy conversion efficiencies in direct sunlight up to 9.15%. The development of these high-efficiency solar cells was based on the analysis of the losses of 7.8% cells. Design changes were based on the application of the loss minimization technique, which led to the development of technology which (1) selectively corrected the losses in the conversion of sunlight directly into current, and (2) reduced the power losses at the maximum power point. This paper describes the technique utilized to analyze the losses, the technology developed to selectively correct these losses and the first results of solar cells fabricated based on this design. Further application of this loss minimization technique predicts that solar cell design changes, along with technology development, can lead to thin film cadmium sulfide photovoltaic solar cells with more than 10% energy conversion efficiency in direct sunlight. (Author)

A79-40950 * **An overview of photovoltaics for space applications.** J. Scott-Monck (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 421-428. 10 refs.

Significant progress in both silicon and GaAs technology for photovoltaic applications has been made. As a result 50 micron silicon cells, incorporating all the recent processing advancements, have been produced which deliver over 19 mW/sq cm initial power. These cells also display impressive performance after exposure to 1 MeV electrons, delivering 15 mW/sq cm after a fluence of 1×10 to the 15th e/sq cm. GaAlAs cells are now being made which have conversion efficiencies and radiation resistance superior to the best silicon solar cells. A discussion of the work that led to this situation, as well as an attempt to project further progress in both silicon and GaAs technology is given. (Author)

A79-40951 * **High efficiency solar panel /HESP/.** P. M. Stella, C. Gay, F. Uno (Spectrolab, Inc., Sylmar, Calif.), and J. Scott-Monck (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; Spectrolab, Inc., Sylmar, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8,

1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 429-437. 7 refs. Contract No. F33615-75-C-2028.

A family of high efficiency, weldable silicon solar cells, incorporating nearly every feature of advanced cell technology developed in the past four years, was produced and subjected to space qualification testing. This matrix contained both field and non-field cells ranging in thickness from 0.10 mm to 0.30 mm, and in base resistivity from nominal two to one hundred ohm-cm. Initial power outputs as high as 20 mW/sq cm (14.8% AM0 efficiency) were produced by certain cell types within the matrix. (Author)

A79-40952 **Testing of ultra-thin solar cells.** D. J. Curtin and R. W. Cool (COMSAT Laboratories, Clarksburg, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 438-443. 11 refs. Research sponsored by the International Telecommunications Satellite Organization.

Thin (50- and 100- micron) silicon solar cells in the power range of 60-62 mW and 74-76 mW were tested with and without coverslips and compared with satellite cells. The solar cells were subjected to 1000 hr of humidity, 12 thermal shock cycles between -196 C and 100 C, tape peel, and electron irradiation to a dose of 3×10 to the 15th e/sq cm. Humidity, thermal shock, and tape peel did not cause electrical degradation. The 50-micron covered cells, which degraded the least under electron irradiation, had a residual power density of 12.5 mW/sq cm compared to 14.0 mW/sq cm for thick (250-micron) sculptured surface cells after a dose of 3×10 to the 15th e/sq cm. (Author)

A79-40953 * **Thin silicon solar cell performance characteristics.** C. F. Gay (Spectrolab, Inc., Sylmar, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 444-449. 11 refs. NASA-sponsored research.

Refined techniques for surface texturizing, back surface field and back surface reflector formation were evaluated for use with shallow junction, single-crystal silicon solar cells. Each process was characterized individually and collectively as a function of device thickness and bulk resistivity. Among the variables measured and reported are open circuit voltage, short circuit current and spectral response. Substantial improvements were obtained by the utilization of a low cost aluminum paste process to simultaneously remove the unwanted n(+) diffused region, form the back surface field and produce an ohmic contact metallization. The highly effective BSF which results from applying this process has allowed fabrication of cells 0.05 mm thick with initial outputs as high as 79.5 mW/4 sq cm (28 C, AM0) and superior electron radiation tolerance. Cells of 0.02 mm to 0.04 mm thickness have been fabricated with power to mass ratios well in excess of 2 watts per gram. (Author)

A79-40954 **Silicon foil cells.** F. Ho and P. A. Iles (Optical Coating Laboratory, Inc., City of Industry, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 454-458. 7 refs.

In 1973 a small number of 4 sq cm silicon cells around 2 mils thick, achieved 60 mW output (AM0). At that time it was speculated that with improved cell techniques power levels around 70 mW would be possible. In recent years, the advanced techniques incorporated in the violet cell comprising shallow PN junctions, close-space narrow gridlines and improved AR coatings have been combined with improved etch-thinning methods to fabricate thin cells with increased output. In addition, other current cell techniques including the use of surface texturing, back surface reflectors, or improved back surface fields have also been applied to produce thin cells of high output or in fairly large numbers. This paper discusses the present state-of-the-art and some implications of these thin cell results. (Author)

A79-40955 Characterization of vertical-junction silicon solar cells. J. Wohlgemuth and C. Wrigley (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 459-462. 5 refs. Contract No. F33615-76-C-2058.

Non-reflective vertical-junction silicon solar cells have been fabricated with high conversion efficiency and superior radiation-resistance. New techniques of oxidation and the use of photolithography enable the use of an orientation dependent etch producing grooves 5-10 microns wide and over 100 microns deep. These silicon wafers are then processed into solar cells with all of the processes performed at temperatures compatible with producing high efficiency solar cells. These vertical-junction silicon solar cells have exceeded 14% AMO efficiency and have shown superior radiation resistance, resulting in cells with high end-of-life efficiency. Recent work on process technology has resulted in a significant reduction in process time and higher fabrication yields. Since the cells can now be reliably fabricated in quantity, many cell parameters are under investigation.

(Author)

A79-40957 * Growth, evaluation and modeling of silicon-on-ceramic solar cells. J. D. Zook, S. B. Schuldt, R. B. Macielek, and J. D. Heaps (Honeywell Corporate Material Sciences Center, Bloomington, Minn.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 472-478. 15 refs. Research sponsored by the U.S. Department of Energy and NASA.

The silicon-on-ceramic (SOC) process uses inexpensive ceramic substrates to provide supported growth of silicon from the melt. The conditions for unidirectional solidification, the grain structure and other properties are quite similar to those of EFG silicon ribbon. Solar cells with interdigital electrodes have demonstrated AMI conversion efficiencies (active area) of 7.8% without AR coatings and 10.1% efficiencies with an AR coating of SiO₂. Mathematical modeling of the series resistance of cells shows the feasibility of making electrical contact to the base layer of the cell through slots in the substrate. However, series resistance in the base layer sets an upper limit on slot spacing for efficient cell performance. (Author)

A79-40958 Comparison between epitaxial and diffused solar cells on crystalline substrates grown from metallurgical-grade silicon. T. Saitoh, N. Nakamura, H. Itoh, S. Matsubara, T. Warabisako, and T. Tokuyama (Hitachi, Ltd., Central Research Laboratory, Kokubunji, Tokyo, Japan). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 479-484. 12 refs. Research supported by the Ministry of International Trade and Industry.

The photovoltaic characteristics of epitaxial and diffused solar cells are compared. The cells are fabricated on monocrystalline substrates that are Czochralski-grown from metallurgical-grade silicon. AMI conversion efficiencies of more than 7% are obtained for 20 sq cm area epitaxial cells, whereas the efficiencies of diffused cells are less than half these values. Low minority carrier diffusion length due to the secondary impurities in the substrates is considered the main reason for the low efficiency of diffused cells. This is confirmed by impurity analysis data obtained through spark source mass spectroscopy. The photocurrent image obtained using scanned laser beams indicates the existence of a swirl-like pattern in the diffused cells. On the contrary, very homogeneous photocurrent images are obtained for epitaxial cells. To improve minority carrier diffusion length, epitaxial drift-field cells are fabricated. Maximum conversion efficiencies of 7.8% and 8.6% are realized for 20 sq cm area cells on the monocrystalline substrates from commercial and 'refined' metallurgical silicon, respectively.

(Author)

A79-40959 Efficient polycrystalline solar cells made from low-cost refined metallurgical silicon. J. I. Hanoka, H. B. Strock, and P. S. Kotval (Union Carbide Technical Center, Tarrytown, N.Y.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June

5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 485-489. 7 refs.

A key element in reaching the goal of low-cost terrestrial solar cells is the availability of an inexpensive substrate material. Polycrystalline substrates made from Refined Metallurgical Silicon (RMS) are an attractive candidate. Accordingly a low-cost process for producing RMS has been developed. The resulting RMS substrate material is p-type with resistivity of about 0.1 ohm-cm; major impurities are Fe, Ti, Cu, C, Al, B, and P. Diffused junction solar cells (n plus/p structure) have been fabricated on polycrystalline RMS substrates. AMI efficiencies as high as 8.5% on cells of 4 sq cm area have been obtained with fill factors of 72% and diode quality factors $n = 1.56$ and $J_0 = J_{sub 0} = 1.3 \times 10^{-13}$ times 10 to the minus 8th A/sq cm. An explanation for the rather high efficiencies obtained is suggested in which impurity segregation at the grain boundaries, including twin boundaries, plays a major role.

(Author)

A79-40960 * Characterization of the effects of metallic impurities on silicon solar cell performance. J. R. Davis, A. Rohatgi, P. Rai-Choudhury, P. Blais, R. H. Hopkins (Westinghouse Research and Development Center, Pittsburgh, Pa.), and J. R. McCormick (Dow Corning Corp., Midland, Mich.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 490-495. Contract No. JPL-954331.

The effects of controlled concentrations of secondary impurities (Al, C, Ca, Cr, Cu, Fe, Mg, Mn, Mo, Ta, Ti, V, Zn, and Zr), incorporated alone or in combinations into Czochralski and float zone crystals, on the performance of silicon solar cells were investigated. Impurity concentrations ranged from 10 to the 11th to 10 to the 17th/cu cm. Solar cells were fabricated by a conventional diffusion process and characterized by computer reduction of current-voltage data. The data suggest that performance loss primarily results from reduction of the base diffusion length. On the basis of this assumption, a first order analytic model which predicts cell performance as a function of impurity concentrations is developed. Calculated performance parameters are in good agreement with observation, except for some impurities, such as Fe, Cu and Ni, which degrade cells via recombination and defects in the junction space-charge region. N-base devices are less affected by impurities, although degradation mechanisms appear to be the same as in p-devices. There seems to be very limited interaction between impurities in multiply-doped cells.

C.K.D.

A79-40961 * The effects of copper and titanium on silicon solar cells. A. M. Salama (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 496-502. 10 refs. Research sponsored by the U.S. Department of Energy and NASA.

Copper-doped N/P silicon solar cells fabricated from the Czochralski grown single-crystal wafers were found to have good electrical characteristics, but the titanium-doped N/P silicon solar cells has considerably lower conversion efficiency. However, in the copper/titanium-doped solar cells, copper seems to mitigate the unfavorable effects of titanium. To explain this behavior, microstructural tests were performed on silicon wafers and solar cells doped with copper, titanium and copper/titanium. Dark forward and reverse I-V measurements were performed on the solar cells to correlate the microstructural defects with the p-n junction properties. It was found that copper precipitates were formed in the copper-doped and copper/titanium-doped wafers and cells. There was a significant voltage drop in the dark reverse I-V measurements of the titanium solar cells. Also, there were some electronically active defects in the depletion region of some titanium-doped cells. Reasons that lead to the above results are given in detail.

(Author)

A79-40962 * Effect of copper impurity on polycrystalline silicon solar cells. T. Daud and K. M. Koliwad (California Institute of

Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 503-506. 6 refs. Contract No. NAS7-100.

The presence of copper impurity, up to 10 to the 15th atoms/cc, in single crystal silicon has been shown to have no deleterious effect on the p-n junction solar cell performance. However, in polycrystalline silicon, copper atoms tend to migrate to the defect sites because of the structural sensitive properties of copper. This study was undertaken to investigate the influence of this behavior of copper impurity on the performance of p-n junction solar cells fabricated from structurally imperfect silicon. Two sets of polycrystalline silicon substrates containing copper were examined. In one set of samples, copper was incorporated during growth, whereas in the other, copper was diffused. Solar cells were fabricated on both the sets of substrates by a standard process. Dark and light I-V and spectral response characteristics of the cells were measured and compared with copper-free polycrystalline silicon solar cells. The results and the model are discussed. (Author)

A79-40963 Characteristics of Cu(x)/S/CdS cell on sprayed thin CdS films. V. P. Singh (Photon Power, Inc., El Paso, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 507-512. 21 refs.

Thin films (4 microns) of CdS deposited by spray pyrolysis on tin oxide exhibit a resistivity of 134 ohm cm and electron mobility of 3.9 sq cm/Vsec. Cu(x)S/CdS cells made on these have a depletion layer width of 0.74 microns in dark and 0.23 microns under AM1 illumination. Space charge density is 1.4 times 10 to the 15th/cu cm in dark and 1.2 times 10 to the 16th/cu cm in light. Diffusion voltage is estimated at 0.8 volts. The dominant forward current mechanism in light is found to be a multi-step tunneling-recombination current in the temperature range -66 C to 25 C. The existence of a multitude of closely spaced trap levels in the CdS band gap, close to interface, is required for this tunneling to occur. (Author)

A79-40964 The effects of MISFIT dislocations on the photovoltaic properties of CdS based solar cells. K. A. Jones, C. H. Cheng, and B. F. Shirreffs (Dartmouth College, Hanover, N.H.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 513-518. 7 refs. NSF Grant No. DMR-75-09329.

The lattice mismatch between a basally textured Zn(x)Cd(1-x)S substrate and a Cu2S film and between a basally textured CdS(1-y)Se(y) substrate and an InP film is calculated for different compositions, degree of surface roughness, and type of surface roughness. The mismatch is converted into a relative recombination velocity by comparing the mismatch for different substrates with that of a smooth substrate for which the compositional variable (x or y) is zero. It is shown that the mismatch can be smaller for a rough substrate at one composition and larger at another, that the mismatch can be reduced essentially to zero by varying the composition only when the substrate is smooth, and that the lattice distortion across the nonbasal planes is more severe than it is across the basal planes. (Author)

A79-40965 Barrier heights and interfacial effects in SnO2/Si solar cells. T. Feng, C. Fishman, and A. K. Ghosh (Exxon Research and Engineering Co., Linden, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 519-523. 12 refs. Contract No. E(04-3)-1283.

Efficiencies exceeding 12% have been observed for SnO2/Si solar cells fabricated by electron beam deposition or spraying. The change in the interfacial oxide layer of these devices during the annealing process is an important factor determining the device performance. A barrier height of 0.8 eV was determined from an

analysis of the temperature dependence of the reverse saturation current. Ultraviolet photoemission spectroscopy was used to determine the work function of SnO2, and C-V measurements were made to determine the diffusion potential of the cell. Corrections must be applied to the diffusion potential determined from C-V data in order to account for the contribution of the oxide thickness and surface states. (Author)

A79-40966 Indium-tin oxide/indium phosphide and indium-tin oxide/gallium arsenide solar cells. K. J. Bachmann, W. R. Sinclair, F. A. Thiel, H. Schreiber, Jr., P. H. Schmidt, E. G. Spencer, W. L. Feldmann, E. Buehler (Bell Telephone Laboratories, Inc., Murray Hill, N.J.), and K. S. Sreeharsha (San Jose State University, San Jose, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 524-527. 23 refs.

Indium-tin oxide (ITO)/GaAs and ITO/InP solar cells have been fabricated via ion beam deposition, rf sputtering and magnetron sputtering of amorphous and polycrystalline ITO films on single crystal p-type GaAs and InP substrates, respectively. The AM2 efficiency for ITO/InP solar cells fabricated at room temperature is about 14% while ITO/GaAs solar cells have efficiencies of about 5%. (Author)

A79-40967 The photovoltaic effect in interfacial layer heterojunctions or semiconductor-insulator-semiconductor diodes - Indium-tin-oxide on silicon, gallium arsenide and indium phosphide. J. Shewchun, R. Singh, D. Burk, M. Spitzer, J. Loferski, and J. Dubow (McMaster University, Hamilton, Ontario, Canada; Brown University, Providence, R.I.; Colorado State University, Fort Collins, Colo.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 528-535. 26 refs. Research supported by the U.S. Department of Energy.

A79-40968 Photovoltaic properties of In2O3/semiconductor heterojunction solar cells. L. Hsu (Rockwell International Corp., Space Div., Downey, Calif.) and E. Y. Wang (Wayne State University, Detroit, Mich.; Rockwell International Corp., Space Div., Downey, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 536-540. 12 refs.

In2O3/Ge, In2O3/Si, In2O3/GaAs, and In2O3/InP heterojunctions formed by a chemical vapor deposition have been investigated. The results show that all devices give a photovoltaic effect and rectifying characteristics. The polarity observed in the open-circuit voltage and short-circuit current is consistent with the band bending of a simple In2O3/semiconductor heterojunction energy band diagram neglecting interface states. An electron affinity of 4.45 eV for In2O3 was obtained from this study. Results of the photovoltaic properties on solar cells using various substrates of Si and Ge materials are consistent with the direction energy-band diagram using the obtained electron affinity value for In2O3. (Author)

A79-40969 Fabrication and characterization of ITO/CuInSe2 photovoltaic heterojunctions. L. L. Kazmerski and P. Sheldon (Solar Energy Research Institute, Golden, Colo.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 541-544. 8 refs. NSF-supported research.

The photovoltaic effect in indium-tin-oxide (ITO)/CuInSe2 heterostructures has been demonstrated. An AM1 efficiency of 8.5% has been measured for a single crystal device. The thin-film analogue had a conversion efficiency of 2.08%. Although the photovoltaic effect was observed in devices with ITO deposited at room temperature, improved performance resulted at a substrate temperature of about 180 C. Degradation in short-circuit current was noted after operation at 200 C for 10 hours in air ambient. (Author)

A79-40971 # Air Force High Efficiency Solar Panel - GaAs cell development. C. Stuerke (USAF, Aero Propulsion Laboratory, Wright-Patterson AFB, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 551-556. 13 refs.

The Air Force Aero Propulsion Laboratory is sponsoring the development of a High Efficiency Solar Panel. The cell development phases of this program are aimed at demonstration of 16% solar cell efficiency with 1 MeV electron damage of less than 13% after 3 times 10 to the 14th electrons/sq cm. This paper presents the progress to date and describes future development tasks. Test results include measurement of cell solar absorptance, spectral response, temperature stability, and cell efficiency as well as some radiation damage. Satellite power system benefits available through use of this development are discussed. (Author)

A79-40972 Proton and electron irradiations of liquid phase epitaxial GaAlAs solar cells. L. S. Pearce, L. Hsu, J. Lowe (Rockwell International Corp., Space Div., Downey, Calif.), and R. Sahai (Rockwell International Science Center, Thousand Oaks, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 557-561. 6 refs. USAF-supported research.

About 330 GaAlAs solar cells with junction depths in three ranges (1 to 1.5; 1.5 to 2.5; 2.5 to 3.5) and efficiencies of at least 10% were irradiated with 0.5 MeV and 1.00 MeV electrons and protons with energies of 0.2 MeV, 0.45 MeV, 0.65 MeV, 1.00 MeV, 3.00 MeV and 10 MeV. The cells were characterized before and after irradiation and after annealing. Annealing was carried out for 65 to 130 hours at 130 to 160 C. In comparison with silicon cells, the GaAlAs cells were found to be relatively susceptible to damage by protons with energies below 3-MeV. However, cells with junction depths of 1 to 2 microns were found to be about 3 times harder than silicon cells to high-energy electrons capable of penetrating a 4-mil cover glass. It was found that up to 60 percent recovery could be obtained by annealing shallow junction cells for 130 hours at 130 C. Similar recoveries were observed after 34 hours at 160 C or 3 hours at 240 C. C.K.D.

A79-40973 * Electron and proton degradation in AlGa/As-GaAs solar cells. R. Loo, R. C. Knechtli, G. S. Kamath (Hughes Research Laboratories, Malibu, Calif.), L. Goldhammer (Hughes Research Laboratories, Malibu; Hughes Aircraft Co., El Segundo, Calif.), and B. Anspaugh (California Institute of Technology, Jet Propulsion Laboratory, Pasadena; Hughes Research Laboratories, Malibu, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 562-570. Contract No. NAS1-14727.

Results on radiation damage in (AlGa)As-GaAs solar cells by 1 MeV electron fluences up to 10 to the 16th electrons/sq cm and by 15, 20, 30 and 40 MeV proton fluences up to 5 times 10 to the 11th protons/sq cm are presented. The damage is compared with data on state-of-the-art silicon cells which were irradiated along with the gallium arsenide cells. The theoretical expectation that the junction depth has to be kept relatively shallow, to minimize radiation damage has been verified experimentally. The damage to the GaAs cells as a function of irradiation, is correlated with the change in their spectral response and dark I-V characteristics. The effect of thermal annealing on the (AlGa)As-GaAs solar cells was also investigated. This data is used to predict further avenues of optimization of the GaAs cells. (Author)

A79-40975 Preliminary evaluation of a GaAlAs solar concentrator space power unit. J. Lowe, L. Pearce, R. Miller, and E. French (Rockwell International Corp., Space Div., Downey, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 580-585. Contract No. F33617-77-C-3130.

The results of fabricating, testing and analysis of a GaAlAs concentrator system are presented. These results include analysis of curves of efficiency versus concentration ratio and cell efficiency versus temperature. Further analysis is presented which led to the design of a space power module capable of being integrated into satellite power systems and include mirror geometry and materials studies, radiator and cell stack design. Survivability analyses are presented and include a comparison of GaAlAs cells inherent hardness to natural radiation, electrons and protons, with that of silicon solar cells, and the additional hardness provided by the concentrator. Data are presented which indicate the extent of recovery of solar cell power due to self-annealing of radiation damage at the elevated temperatures available in the concentrator system. During infrared radiation, a concentrator is shown significantly harder than a planar array. A thermal analysis is presented which shows the ability of the concentrator module to survive temperatures which could destroy a planar array. (Author)

A79-40977 Screen printed contacts on silicon solar cells with low series resistance. L. Frisson, P. Lauwers, P. Bulteel, L. de Smet, R. Mertens, R. Govaerts, and R. van Overstraeten (Leuven, Katholieke Universiteit, Heverlee, Belgium). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 590-592. Research supported by the Instituut tot Aanmoediging van het Wetenschappelijk Onderzoek in Nijverheid en Landbouw and Nationale Fonds voor Wetenschappelijk Onderzoek.

A vacuum free silicon solar cell fabrication process, using screen printing for metallization, has been developed. Excellent open circuit voltages (609 mV) and fill factors (.76) have been obtained on large area cells. AM1 efficiencies of 12% have been reached. Optimum sheet resistances of the diffused layer seem somewhat lower than for evaporated cells. Screen printing seems not to introduce an additional contact resistance. Cells fabricated with this technology could be used under concentrated sunlight for concentration factors up to 30. (Author)

A79-40978 Contact resistance of silver ink on solar cell. H. C. Lin (Maryland, University, College Park, Md.), D. P. Spittlehouse, and Y. W. Hsueh (McGraw Edison Co., Bristol, Conn.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 593-596.

The presence of oxygen in the firing process for silver ink as well as in the compound can oxidize the silicon surface and create a poor ohmic contact. The contact resistance to the n(+) diffused layer was measured. It was found that the contact resistance tends to be inversely proportional to the periphery length of the contact rather than the area of the contact. This fact seems to indicate that the contact is more intimate at the edges of the contact. Scanning electron microscope photomicrograph seems to confirm these findings. These results also suggest how the contact pattern should be designed. A three point probe method was used to measure the resistance of the n(+) layer contact. By measuring the terminal V-I characteristic of the solar cell, the contact resistance of the n(+) contact and the p(+) contact can be separately determined. (Author)

A79-40979 * The Pd2Si - /Pd/ - Ni - solder plated metallization system for silicon solar cells. M. G. Coleman, R. A. Pryor, and T. G. Sparks (Motorola, Inc., Semiconductor Group, Phoenix, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 597-602. 7 refs. Research supported by the U.S. Department of Energy; Contract No. JPL-954689.

The rationale and application of a plated metal system, Pd2Si - Pd - Ni - solder, is presented. This metallization system is particularly useful on shallow p-n junction solar cells. The advantages of such plated solar cell contacts are discussed. A process sequence for

applying the metallization system is outlined. A specific example is presented, including chemical plating solution formulations and detailed process step descriptions. Electrical test data for solar cells metallized with the palladium-nickel-solder system are provided.

(Author)

A79-40980 Evaluation of thick film materials for use as solar cell contacts. D. E. Riemer (Boeing Co., Seattle, Wash.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 603-608. 5 refs.

Successful use of thick film contacts for silicon solar cells under optimized processing condition requires extensive testing. It is recommended to replace the evaluation of actual cells by the fabrication of small test chips which can be obtained in quantity from one wafer. The processing sequence of the test chips could be identical to that considered for the fabrication of actual cells. A special metallization pattern has been designed which can provide numerical information on contact performance. It can be used to measure line and contact resistance while testing the effects of the contacts on the silicon substrate.

(Author)

A79-40981 Optimizing solar cell performance by simultaneous consideration of grid pattern design and interconnect configuration. H. B. Serreze (Mobil Tyco Solar Energy Corp., Waltham, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 609-614. 7 refs.

A79-40982 * Evaluations of candidate encapsulation designs and materials for low-cost silicon photovoltaic arrays. G. B. Gaines, D. C. Carmichael, F. A. Sliemers, M. C. Brockway, A. R. Bunk, and G. P. Nance (Battelle Columbus Laboratories, Columbus, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 615-619. Contract No. NAS7-100.

Three encapsulation designs for silicon photovoltaic arrays based on cells with silk-screened Ag metallization have been evaluated: transparent polymeric coatings over cells laminated between two films or sheets of polymeric materials; cells adhesively bonded to a glass cover with a polymer pottant and a glass or other substrate component. Silicone and acrylic coatings were assessed, together with acrylic sheet, 0.635 mm fiberglass-reinforced polyester sheet, 0.102 mm polycarbonate/acrylic dual-layer film, 0.127 mm fluorocarbon film, soda-lime glass, borosilicate glass, low-iron glass, and several adhesives. The encapsulation materials were characterized by light transmittance measurements, determination of moisture barrier properties and bond strengths, and by the performance of cells before and after encapsulation. Silicon and acrylic coatings provided inadequate protection. Acrylic and fluorocarbon films displayed good weatherability and acceptable optical transmittance. Borosilicate, low-iron and soda-lime-float glasses were found to be acceptable candidate encapsulants for most environments.

C.K.D.

A79-40983 * A low cost, durable anti-reflective film for solar collectors. E. M. Pastirik and M. C. Keeling (Motorola, Inc., Semiconductor Group, Phoenix, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 620-623. 7 refs. Research supported by the U.S. Department of Energy; Contract No. JPL-954773.

The physics of reflection reduction by thin films is briefly reviewed. Current techniques for the production of anti-reflective coatings are surveyed with respect to their applicabilities to solar panel covers. Techniques for the production of suitable anti-reflection coatings based on acid-hardened sodium silicate solutions

are presented along with optical data for both acid-leached and silicate coatings.

(Author)

A79-40985 Experimental and theoretical study of silicon MOS solar cells with different barrier metals. S. Kar, D. Shanker, S. P. Joshi, and S. Bhattacharya (Indian Institute of Technology, Kanpur, India). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 628-633. 15 refs.

The aim of this paper is to present a comprehensive theory for MOS solar cells based on experimental data. Relationships for the open-circuit voltage have been derived which indicate that an increase in the silicon band-bending along with the expected increase in the oxide potential barrier can be held mainly responsible for the many orders of magnitude reduction in the majority carrier diode current and for the subsequent enhancement of the open-circuit voltage. The minority carrier photocurrent remains undisturbed so long as the rate of minority carriers tunneling through the oxide is larger than their rate of supply to the interface. Experimental data obtained from MOS solar cells with various barrier metals and at various values of light intensity and temperature support the above theory.

(Author)

A79-40986 Experimental critique of the simple Schottky theory of metal-silicon solar cells using a range of metals and illumination levels. P. Panayotatos and H. C. Card (Columbia University, New York, N.Y.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 634-638. 11 refs.

A79-40987 Formation and stability of MS or MIS Schottky solar cells. J. P. Ponpon and P. Siffert (CNRS, Group de Physique et Applications des Semiconducteurs, Strasbourg, France). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 639-644. 12 refs.

The ageing of Schottky barriers in metal semiconductor (MS) and metal-thin insulator-semiconductor solar cells has been investigated. I-V measurements were made for a variety of cells (Au or Bi on n-type silicon and Pb or Al on p-type silicon), and these results were compared with the oxygen distributions at the interface as determined by several ion beam techniques. It is shown that formation of the Schottky barrier at the metal silicon contact and the long term stability of the devices are correlated to the diffusion of oxygen or water vapour through the metal. When diffusion occurs, I-V properties of the cell are strongly time-dependent, and it behaves like a MIS device. When the metal is easily oxidized and diffusion is limited, practically no ageing is observed over long periods of time; a MIS device with a very thin interfacial layer is formed rather than a 'true' Schottky barrier. In gold n-type silicon devices, a positive charge associated with the oxygen-impooverished native oxide layer reduces the potential barrier after gold deposition. Upon exposure to air, oxygen or water vapour migrates to the interface, where its neutralization of the positive charge increases the barrier height. With prolonged exposure, diffusing ions oxidize the silicon and a MIS structure is formed.

C.K.D.

A79-40988 Transport and ultra-thin insulator studies for MIS solar cell structures on silicon and gallium arsenide. S. J. Fonash, T. E. Sullivan, R. Childs, and J. Ruths (Pennsylvania State University, University Park, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 645-650. 9 refs.

A79-40989 The short-wavelength response of single- and poly-crystalline MIS solar cells. M. A. Green, R. B. Godfrey, and L. W. Davies (New South Wales, University, Kensington, Australia). In:

Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 651-655. 8 refs. Research supported by the Australian Research Grants Committee, Utah Foundation, Electrical Research Board, Radio Research Board, and Sydney County Council.

It is shown that while there is the possibility of a low collection efficiency or 'dead' layer in intimate Schottky solar cells, the presence of a thin insulating layer makes this unlikely in MIS cells. Hence in addition to its well established effect of substantially increasing the open circuit voltage of Schottky cells, the thin insulating layer in MIS cells may also marginally increase the short circuit current by virtue of an improved short-wavelength response. Grain boundaries are shown to be particularly ineffective recombination sites in depletion regions and this leads to a similarly good short-wavelength response for polycrystalline MIS cells. Finally, grating MIS cells are described which display AM1 efficiencies based on active area of 10.5% and 13.9% for 4-sq cm cells on poly- and single-crystalline silicon respectively. (Author)

A79-40990 An MIS photovoltaic cell with silicon nitride insulator. E. J. Charlson and W. F. Richardson (Missouri-Columbia, University, Columbia, Mo.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 656-660. 12 refs.

A new low temperature process for growing silicon nitride on silicon has been developed. The process involves direct surface nitridation with monatomic nitrogen produced by electrical discharge. The low temperature nitridation has been used to produce the insulator in Al/p-type Si MIS solar cells. At AM 1 these cells have open circuit voltages from 0.45-0.48 volts and short circuit currents in the range of 20-30 ma/sq cm. Fill factors of 70% can be routinely produced, yielding absolute conversion efficiencies of 8-9%. The largest conversion efficiency produced to date has been 10.2%. The response to monochromatic light has been measured for visible light and indicates an enhanced blue response. TEM micrographs show a very smooth surface. Solar cell life has not been extensively investigated but the rate of deterioration is considerably less than similar cells with silicon oxide insulators. (Author)

A79-40991 Analysis of ion-implanted solar cells. Y. P. Pai and H. C. Lin (Maryland, University, College Park, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 661-664. 7 refs. NSF Grant No. ENG-76-09933.

When ions are implanted to invert the surface of a semiconductor substrate and a metal contact is deposited on the implanted layer, the solar cell thus formed can be either a Schottky barrier or a p-n junction. This analysis shows that at low dosage, ion-implantation serves to increase the barrier height of a Schottky barrier. At high implantation dosages, the current transport mechanism is the same as that of a junction in that the diffusion current dominates. The optimum dosage and range should consider both a high open-circuit voltage and a low sheet resistivity of the implanted layer. (Author)

A79-40992 Recombination effects in p-type silicon Schottky barrier solar cells. P. T. Landsberg and C. M. Klimpe (Southampton, University, Southampton, England). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 665, 666. NATO-supported research; Grant No. AF-AFOSR-77-3437.

A79-40993 Design of a 10kW photovoltaic 200/1 concentrator. H. A. Wilkening (AAI Corp., Baltimore, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 669-672.

The AAI Corporation photovoltaic concentrator is a 200/1 optical solar concentrator coupled with a compatible array of Solarex Corporation 200X photovoltaic cells, using a fluid loop heat transfer system for cooling the cells. The concentrator will consist of a mounting frame, reflectors mounted in pivoting gimbals, and a receiver/photovoltaic cell assembly. The tracking system consists of mechanical drives and linkages, and a control system which provides for tracking the elevation and azimuth motion of the sun. An emergency fail-safe secondary reflector system prevents damage to the photovoltaic receiver array in any type of malfunction. (Author)

A79-40994 Fresnel optics for solar concentration on photovoltaic cells. L. W. James (Varian Associates, Inc., Palo Alto, Calif.) and J. K. Williams (Optical Sciences Group, San Rafael, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 673-679. 5 refs.

The economic viability of concentrator photovoltaic systems depends on maintaining a high cell conversion efficiency, a high optics transmission (or reflection) efficiency, and a low structure cost per unit area. The conversion efficiency of concentrator solar cells is shown, both theoretically and experimentally, to be reduced by illuminating the cells with a nonuniform flux density. The structure cost is reduced by increasing the allowable tracking error. Thus flux density uniformity, optical transmission, allowable tracking error, cost per unit area, and lifetime are the important criteria for photovoltaic concentrating optics. Acrylic Fresnel lens designs are discussed in terms of these criteria. (Author)

A79-40995 Evaluation of a plastic parabolic concentrator for terrestrial photovoltaic applications. D. K. Zimmerman (Boeing Co., Seattle, Wash.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 680-685. Research supported by the U.S. Department of Energy.

The experimental evaluation of an air pressure stabilized plastic film parabolic concentrator is described. The study objectives were to determine the fabrication feasibility and optical performance of the concentrator. This was the first step toward developing a concentrating photovoltaic array for terrestrial power production. The concentrator was made from gores of aluminized polyester film supported on a lightweight framework. Shape of the reflector is maintained by a slight vacuum back of the reflective surface. The concentrator and receiver are enclosed by an inflated dome of transparent plastic film, which provides wind and weather protection for the array and concentrator. Three concentrators were fabricated and two were optically tested. A laser ray trace of the concentrators was used to determine local deviations of the surface slope, the best optical axis, and the best focal plane. The concentration ratio, image quality, and overall efficiency of the concentrators were determined using a solar simulator. The results indicate that concentration ratios well above the 200:1 goal can be achieved. (Author)

A79-40996 A novel low-cost photovoltaic concentrator. W. Masters, R. Maraschin, and W. Kennedy (Acurex Corp., Mountain View, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 686-689. U.S. Department of Energy Contract No. 07-6922.

Acurex has developed a photovoltaic concentrator design that is fully compatible with automobile-headlight production technology. Like a headlight, the concentrator unit consists of two molded glass halves: one a reflector with appropriate optical contour and a metallized reflective surface, the other a clear glass cover. The solar cell is mounted on a liquid cooled substrate fused into the glassware. The two halves are fused together and the interior is filled with inert gas. This paper presents a summary of progress in design and prototype fabrication activities. B.J.

A79-40997 Luminescent solar concentrators. C. F. Rapp and N. L. Boling (Owens-Illinois, Inc., Toledo, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 690-693. 6 refs. U.S. Department of Energy Contract No. 07-6921.

A thin film LSC configuration has been developed which uses a thin luminescent film about 1 mil thick, deposited on an undoped glass or plastic substrate several mm thick. In this configuration, absorption and emission occur only in the thin film rather than throughout the substrate. The luminescence, however, is trapped in the entire film-substrate composite, thereby minimizing the amount of reabsorption of the luminescence by the dye. Several 6-in.-square plates have been constructed with fluorescent plastic and collector conversion efficiencies of several percent have been achieved. B.J.

A79-40998 Passive cooling for linearly concentrated solar cell arrays. R. C. Williams and B. D. Wood (Arizona State University, Tempe, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 694-699. 8 refs. U.S. Department of Energy Contract No. 05-6037.

Experimental results are presented to identify the potentialities and limitations of using extruded aluminum finned heat sinks to provide passive cooling for linear concentrator photovoltaic power systems. A single row and a double row silicon solar cell array designed for maximum output at 25 suns were tested in a fixed mirror solar concentrator testbed. Tests were run with four different finned heat sinks under varying concentration intensities, wind speed and direction, and ambient conditions. System electrical performances are reported in addition to the heat sink thermal data and cooling effectiveness. Heat transfer coefficients were determined as a function of wind speeds and directions. Data were obtained for extreme design conditions such as maximum intensity at zero wind speeds and for temperature rises along the array when the wind velocity is parallel to the focal line. (Author)

A79-40999 Source tracking and power flow control of terrestrial photovoltaic panels for concentrated sunlight. P. L. Swart and J. D. van Wyk (Rand Afrikaans University, Johannesburg, Republic of South Africa). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 700-705. 9 refs. Research supported by the South African Council for Scientific and Industrial Research and Rand Afrikaans University.

A tracking system for concentrator photovoltaic panels is discussed. It employs a sun-sensing system and structural controller which activate either one of four modes of control, namely searching, tracking, waiting and shut-down. The power from the solar panel is passed through electronic power converters of the buck or boost type to achieve the necessary conditioning. These converters form part of a self-adaptive extremal control system continuously adjusting the changing solar generator impedance to the load impedance for maximum power transfer. The development of special high-efficiency concepts employing power transistor choppers, together with a tracking system which is activated only periodically, lead to a power loss of only 2% in the modular power packages designed for solar panels of nominally 200W, 60V. (Author)

A79-41000 * Production technology for high efficiency ion implanted solar cells. A. R. Kirkpatrick, J. A. Minnucci, A. C. Greenwald (Spire Corp., Bedford, Mass.), and R. H. Josephs (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 706-710. Research supported by the U.S. Department of Energy and NASA.

Ion implantation is being developed for high volume automated production of silicon solar cells. An implanter designed for solar cell processing and able to properly implant up to 300 4-inch wafers per hour is now operational. A machine to implant 180 sq m/hr of solar cell material has been designed. Implanted silicon solar cells with efficiencies exceeding 16% AM1 are now being produced and higher efficiencies are expected. Ion implantation and transient processing by pulsed electron beams are being integrated with electrostatic bonding to accomplish a simple method for large scale, low cost production of high efficiency solar cell arrays. (Author)

A79-41001 Low cost ion implantation procedure for the realization of silicon solar cells in a continuous way. J. C. Muller, A. Grob, J. J. Grob, R. Stuck, and P. Siffert (CNRS, Groupe de Physique et Applications des Semiconducteurs, Strasbourg, France). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 711-716. 36 refs.

A79-41002 Solar cells from laser-annealed ion-implanted silicon. R. T. Young, C. W. White, J. Narayan, R. D. Westbrook, R. F. Wood, and W. H. Christie (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 717-723. 8 refs. Contract No. W-7405-eng-26.

Annealing by high-power laser pulses is being used to replace conventional furnace annealing for the removal of lattice damage in ion-implanted silicon. Results show that laser annealing can completely remove the lattice damage in the implanted layer without degradation of the minority carrier diffusion length in the substrate. This results in solar cells with improved open circuit voltages and short circuit currents. The dependence of cell parameters and efficiency on such laser parameters as wavelength, energy density, and pulse duration time is currently under investigation. (Author)

A79-41003 A new process for production of shallow diffused silicon solar cells. M. Finetti, P. Ostojic, S. Solmi, and G. Soncini (CNR, Bologna, Italy). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 724-728. 12 refs. Research supported by the Consiglio Nazionale delle Ricerche.

A new technology to form a very shallow front junction in p-type silicon crystal, based on phosphorus diffusion into the semiconductor through a very thin polysilicon layer, is presented. The polysilicon avoids anisotropic interdiffusion phenomenon at the metal-semiconductor interface, so that it allows to use aluminum as front grid contact. Preliminary results obtained on 1 x 1 sq cm solar cell prototypes fabricated by this technology are presented and discussed. (Author)

A79-41004 * Terrestrial solar arrays with integral glass construction. P. R. Younger, W. S. Kreisman, G. A. Landis, A. R. Kirkpatrick (Spire Corp., Bedford, Mass.), and R. F. Holtze (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 729-732. Research supported by the U.S. Department of Energy and NASA.

An excellent encapsulation system for a terrestrial solar array can be formed using two sheets of glass. Superior technical character, very low cost and simple assembly can result if the active components and the glass sheets are integrally bonded together such that the array is hermetically sealed without employing organic encapsulation materials. Such an approach is being developed using electrostatic bonding. Status of this development is described.

Functioning integral glass test modules have been fabricated and subjected to environmental testing. Results have been excellent.

(Author)

A79-41005 * **Optimized solar module design.** T. Santala, R. Sabol, and B. G. Carbajal (Texas Instruments, Inc., Dallas, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 733-737. Contracts No. JPL-954881; No. NAS7-100.

The minimum cost per unit of power output from flat plate solar modules can most likely be achieved through efficient packaging of higher efficiency solar cells. This paper outlines a module optimization method which is broadly applicable, and illustrates the potential results achievable from a specific high efficiency tandem junction (TJ) cell. A mathematical model is used to assess the impact of various factors influencing the encapsulated cell and packing efficiency. The optimization of the packing efficiency is demonstrated. The effect of encapsulated cell and packing efficiency on the module add-on cost is shown in a nomograph form.

(Author)

A79-41006 **A novel photovoltaic panel for low cost power.** Y. Chevalier, F. Dueñas, and I. Chambouleyron (Instituto Politécnico Nacional, Mexico City, Mexico). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 738-743. 11 refs.

Theoretical calculations and experimental results are presented on the behavior of double-illuminated silicon solar cells mounted on a nonconventional panel with front and back illumination. Experimental results are presented on (1) cell structure behavior under different irradiation conditions, base material characteristics and fabrication technology; and (2) the nonconventional panel. Considerable cost/watt reductions are expected from the use of high efficiency thin cells.

B.J.

A79-41007 **The dependence of solar cell characteristics on the electronic properties of discharge produced, hydrogenated amorphous silicon.** C. R. Wronski (RCA Laboratories, Princeton, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 744-750. 18 refs. Contract No. EY-76-C-03-1286.

Discharge produced, hydrogenated amorphous silicon (a-Si:H) such as used in the fabrication of efficient solar cell structures has been recently shown to exhibit a wide range of electronic properties including photo-induced reversible conductivity changes. The contribution of some of these properties to the photovoltaic characteristics and solar cell operation of metal/undoped a-Si:H structures is reviewed. Results are presented on the contribution of junction properties and the effects of reversible conductivity changes on the performance of such cell structures. Consideration is given to the dependence of the principal cell parameters on resistivity, photoconductivity, mobilities and lifetimes of both free carriers as well as the distribution of gap states. Also the effects of trapping and recombination kinetics are considered and examples of their kinetics, mobility-lifetime products and carrier trapping in the cell structure are presented and discussed.

(Author)

A79-41008 **M-I-S solar cells on amorphous silicon.** J. I. B. Wilson, J. McGill, and P. Robinson (Heriot-Watt University, Edinburgh, Scotland). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 751-754. 13 refs. Research supported by the Wolfson Foundation, Science Research Council of England, and Commission of the European Communities.

Amorphous silicon solar cells using a Ti-TiO(x) barrier contact have given efficiencies comparable to those of Schottky cells using

high work function expensive metals like Pt and Pd. Cells 0.07 sq cm in area have efficiencies up to 4.8%, and 1 sq cm cells have efficiencies up to 2.2%, neither with any anti-reflection coating. Both open circuit voltage and short circuit current are enhanced by this addition of about 2 nm of TiO(x). An 8% efficient cell should be possible with this MIS structure when the carrier lifetimes in amorphous silicon are improved.

(Author)

A79-41009 **Surface state and performance evaluation of Schottky barrier solar cells on amorphous silicon.** W. A. Anderson, J. K. Kim, S. L. Hyland (Rutgers University, New Brunswick, N.J.), J. Coleman (Plasma Physics Corp., Locust Valley, N.Y.), and T. Woo. In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 755-760. 13 refs. Research supported by the CDC Research Corp. and Plasma Physics Corp.

Large area (75 sq cm) a-Si films were plasma-deposited on conducting substrates with a thin heavily doped ohmic contact. Semitransparent electrodes and contacts were directly evaporated to form MS structures. MIS structures had an intervening plasma-deposited nitride layer. In general, an increased open-circuit voltage was shown in these n-Si samples. Pd-MIS cells gave an open-circuit voltage of 0.60 V and a short-circuit current of 2.0 mA/sq cm for cells without an A/R coating. MIS structures gave a 0.25-V increased open-circuit voltage compared to MS structures. Dark I-V curves exhibited 2 slopes having n-factors ranging from 1.7 to 4.0. Surface state density values were in the 10 to the 12th - 10 to the 13th/sq cm-eV range for MS devices and the 10 to the 11th - 10 to the 12th/sq cm-eV range for MIS devices using a continuum model.

(Author)

A79-41010 **Polysilicon MIS solar cells with low work function metals.** P. Munz and E. Bucher (Konstanz, Universität, Konstanz, West Germany). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 761-766. 29 refs. Bundesministerium für Forschung und Technologie Contract No. ET-4007-A.

MIS solar cells of p-type silicon with Cr and Y as barrier generating metals are compared. It is shown that the lower work function metal Y leads to a higher open circuit voltage under identical Si-SiO₂ surface preparation and oxidation conditions. The efficiency of cells prepared with polysilicon 'Silso' is shown to be nearly as high as the efficiency of cells prepared with 111-line-type single crystal p-type silicon. This is true for cells formed with Cr as well as for cells formed with Y as the barrier metal.

(Author)

A79-41011 **Influence of the interface upon the properties of ITO/silicon SIS solar cells.** J. DuBow, G. Cheek, A. P. Genis, C. Wilmsen, J. F. Wager (Colorado State University, Fort Collins, Colo.), and J. Shewchun (McMaster University, Hamilton, Ontario, Canada). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 767-773. 17 refs.

SIS solar cells show considerable promise for terrestrial photovoltaic application. The thickness, composition, and electronic properties of this layer are critical determinants of the device conversion efficiency. Theoretical considerations indicate that the effective thickness of the interfacial layer should be 10 to 17 Å. An oxide semiconductor with the proper conductivity, and work function leads to a minority carrier, nonequilibrium induced junction device. An indium tin oxide on p-type silicon device can attain up to 20% efficiency. Auger depth profiling detected the presence of a thin interfacial layer whose composition grades between silicon and silicon dioxide. The presence of contaminants in this interfacial layer seriously degrades device performance. By varying substrate temperature, a maximum in cell efficiency is attained. The temperature at which this maximum is attained depends upon the rate of oxide

growth at the particular oxygen partial pressure. The results obtained are consistent with theoretical predictions and analytical studies of the interface. (Author)

A79-41012 Scanned light spot evaluation of MIS solar cells to treat non-uniform peripheral photocurrents. J. R. Szedon, T. W. O'Keefe, and T. A. Temofonte (Westinghouse Research and Development Center, Pittsburgh, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 774-779. 12 refs. Contract No. EY-76-C-03-1282.

Laser scanned photocurrent response studies are reported for MIS solar cells of the Al-SiO₂-pSi type. Conventionally processed cells, without AR coating, exhibit no inversion layer-related collection beyond the area defined by the thin metal electrode. Nonuniform inversion layer response from distances greater than 1000 microns beyond the thin metal occurs in units deliberately treated in a high temperature ammonia ambient prior to oxidation. Boat-evaporated silicon monoxide AR coatings also give rise to strong, nonuniform inversion layer collection. Unexpected response from tapered edges of grid electrodes in certain geometries can increase inferred values of average short circuit current density by 5 to 10%. In all, the examples cited indicate the value of laser scanned photocurrent response in more accurately determining performance and in understanding operating mechanisms in small experimental MIS cells. (Author)

A79-41013 Photovoltage in concentrator cells. J. Lindmayer and C. Wrigley (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 782-785. 5 refs.

This paper deals with theoretical modelling and experimental evaluation of the open-circuit voltage in silicon solar cells in concentrated sunlight. The voltage improvement which can be realized beyond the usual 60 mV per decade of concentration is strongly dependent on several aspects of carrier lifetime with concentration level and conditions at the back of the cell. Calculations are presented which approximate the results to be expected from exact solutions of nearly intractable nonlinear differential equations prevailing under concentrated sunlight. They show the great importance of a low back-surface recombination velocity in achieving conductivity modulation or majority carrier flooding in the bulk of the cell. If this is achieved the voltage can rise at 120 mV per decade of concentration, but numerous other factors act to restrain this improvement. (Author)

A79-41014 Open circuit voltage of high intensity silicon solar cells. C. Hu and C. Drowley (California, University, Berkeley, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 786-790. 17 refs.

The open circuit voltage is derived as an explicit function of the carrier concentrations at the junction edges through the concept of the quasi-Fermi-levels. Then, the carrier concentrations, and hence the open circuit voltage is studied as a function of the solar concentration ratio. Consideration is given to the limitations of the cells with and without back confinement (back surface field), the importance of effective cooling, and the effects of band narrowing and the cell dimensions. Back confinement cells have higher photovoltages and can operate at higher concentration ratios efficiently for a given cooling scheme. A relatively light 10 to the 15th/cu cm doping is chosen for the sample cells. (Author)

A79-41015 The V-Groove Multijunction solar cell. T. I. Chappell (California, University, Berkeley, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978,

Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 791-796. 9 refs.

A new type of silicon photovoltaic converter has been developed called the V-Groove Multi-Junction (VGMJ) solar cell. The VGMJ solar cell consists of an array of many individual diode elements connected in series to produce a high voltage, low current output. All the elements of the cell are formed simultaneously from a single silicon wafer by V-groove etching. The results of detailed computer simulations predict a conversion efficiency in excess of 24% for this cell when it is operated in sunlight concentrated 100 or more times. The advantages of this cell over other silicon cells include the capability for greater than 20% conversion efficiency with only modest bulk carrier lifetimes, a higher open-circuit voltage, a very low series resistance, a simple one-mask fabrication procedure, and excellent environmental protection provided by a glass front surface. (Author)

A79-41016 Optimization of the geometrical parameters for arrays of tracking solar collectors to give minimum energy cost. G. W. Masden (Walla Walla College, College Place, Wash.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 797-803. U.S. Department of Energy Contract No. 05-6037.

The effect on the cost of energy due to shadowing produced by neighboring collectors on a typical collector in an array is investigated. A cost-performance equation giving a relative cost of energy in terms of collector geometry, array geometry and configuration, collector tracking method and cost parameters of the collector and land is developed. The cost-performance equation is evaluated for a number of tracking methods for collectors having rectangular and circular apertures. For a given tracking method optimum collector and array geometrical relationships exist which minimize the cost of energy produced. Collector arrays that perform at minimum energy cost can be expected to operate with shadows a significant period of the day. The converter system must be designed to be least affected by shadowing. (Author)

A79-41017 Performance of silicon and gallium arsenide concentration cells. D. T. O'Donnell, S. P. Robb, T. T. Rule, R. W. Sanderson, and C. E. Backus (Arizona State University, Tempe, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 804-809. 10 refs. U.S. Department of Energy Contract No. 05-6037.

Preliminary concentration-cells from five different organizations were tested at ASU, with performance measured as a function of solar intensity as well as increasing temperature. Many of the silicon cells were found to have peak efficiencies in the 15-18% range. One Si cell maintained an efficiency of over 17% up to 400 suns. The peak efficiency of the GaAs cell tested was 21.7%. B.J.

A79-41018 Test and evaluation of silicon cells optimized for high efficiency under concentrated sunlight. J. Castle, P. Payne, E. Aerni, and P. Stella (Spectrolab, Inc., Sylmar, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 810-816. 7 refs.

An internal Spectrolab development task is being directed at determining efficiency performance characteristics of silicon n/p concentrator solar cells. The cells being developed utilize advanced design and processing technology, which includes utilization of back surface fields, back surface reflectors, textured front surfaces, improved front contact geometry masks, and dual AR coatings. Selected performance characteristics obtained from this work are presented. Efficiencies of 18.6% at 28 C have been obtained on 2 x 2 cm size cells measured under concentrated simulated sunlight. Efficiencies exceeding 10% at 10 W/sq cm (100 Air Mass 1 (AM1) solar constants) at a cell temperature of 100 C has also been

obtained. Other performance characteristics addressed and evaluated in this program include the efficiency-temperature coefficient and open circuit voltage sensitivity with concentration and temperature. (Author)

A79-41019 * Performance degradation mechanisms and modes in terrestrial photovoltaic arrays and technology for their diagnosis. G. T. Noel, F. A. Sliemers, G. C. Derringer, V. E. Wood, K. E. Wilkes, G. B. Gaines, and D. C. Carmichael (Battelle Columbus Laboratories, Columbus, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p.817-823. Research supported by the U.S. Department of Energy; Contract No. NAS7-100.

Accelerated life-prediction test methodologies have been developed for the validation of a 20-year service life for low-cost photovoltaic arrays. Array failure modes, relevant materials property changes, and primary degradation mechanisms are discussed as a prerequisite to identifying suitable measurement techniques and instruments. Measurements must provide sufficient confidence to permit selection among alternative designs and materials and to stimulate widespread deployment of such arrays. Furthermore, the diversity of candidate materials and designs, and the variety of potential environmental stress combinations, degradation mechanisms and failure modes require that combinations of measurement techniques be identified which are suitable for the characterization of various encapsulation system-cell structure-environment combinations. B.J.

A79-41020 * Some failure modes and analysis techniques for terrestrial solar cell modules. A. Shumka and K. H. Stern (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 824-834.

Analysis data are presented on failed/defective silicon solar cell modules of various types and produced by different manufacturers. The failure mode (e.g., internal short and open circuits, output power degradation, isolation resistance degradation, etc.) are discussed in detail and in many cases related to the type of technology used in the manufacture of the modules; wherever applicable, appropriate corrective actions are recommended. Consideration is also given to some failure analysis techniques that are applicable to such modules, including X-ray radiography, capacitance measurement, cell shunt resistance measurement by the shadowing technique, steady-state illumination test station for module performance illumination, laser scanning techniques, and the SEM. B.J.

A79-41021 * Environmental qualification testing of terrestrial solar cell modules. A. R. Hoffman and R. G. Ross, Jr. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 835-842. 11 refs.

The placement of solar cell modules in various climates and locations throughout the world results in different degrees and combinations of environmental stresses. Coupled with a design lifetime goal of 20 years, early detection and correction of module design deficiencies can result in significantly better long-term economics. This paper describes an environmental test research program for developing qualification requirements and procedures for flat-plate solar cell modules. A multiple iterative approach for establishing and evaluating test requirements is discussed as well as the rationale for the selection of levels and durations for the current qualification tests. The status of study efforts involving optical surface soiling, encapsulation delamination, and voltage bias-humidity testing is reviewed. (Author)

A79-41022 * # Endurance testing of first generation /Block I/ commercial solar cell modules. E. Anagnostou and A. F. Forestieri (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 843-846. Contract No. E(49-26)-1022.

NASA-LeRC has conducted outdoor endurance tests on modules commercially produced as part of the 46-kW purchase of first generation (Block I) modules by the JPL Low Cost Silicon Solar Array Project. Block I modules from four manufacturers were installed at commercial testing sites in Florida, Puerto Rico, and Arizona and at noncommercial sites in Cleveland, Ohio. The conditions endured by these modules included hot and dry, hot and humid, tropical rain forest, sea-air, urban industrial and urban clean; exposures were for periods up to one year. Test results are presented and discussed. B.J.

A79-41023 * # Variation of solar cell sensitivity and solar radiation on tilted surfaces. T. M. Klucher (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 847-852. Contract No. E(49-26)-1022.

An empirical study was performed (1) to evaluate the validity of various insolation models used to compute solar radiation incident on tilted surfaces from global data measured on horizontal surfaces and (2) to determine the variation of solar cell sensitivity to solar radiation over a wide range of atmospheric condition. Evaluation of the insolation data indicates that the isotropic sky model of Liu and Jordan underestimates the amount of solar radiation falling on tilted surfaces by as much as 10%. An anisotropic-clear-sky model proposed by Temps and Coulson was also evaluated and found to be deficient under cloudy conditions. A new model, formulated herein, reduced the deviations between measured and predicted insolation to less than 3%. Evaluation of solar cell sensitivity data indicates small change (2-3%) in sensitivity from winter to summer for tilted cells. The feasibility of using such global data as a means for calibrating terrestrial solar cells as done by Treble is discussed. (Author)

A79-41024 Increased photovoltaic conversion efficiency through use of spectrum splitting and multiple cells. G. W. Masden (Walla Walla College, College Place, Wash.) and C. E. Backus (Arizona State University, Tempe, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 853-858. 12 refs. U.S. Department of Energy Contract No. 05-6037.

Combined losses due to excess photon energy and energy from photons incapable of ionizing charge carriers accounts for over half of the energy entering a conventional solar cell. These losses can be markedly reduced by splitting the spectrum into parts and directing each part to a separate cell with characteristics designed to match the spectral distribution of the incident part. The total conversion efficiency for a two-cell system using a Ga(Al)As/GaAs cell and a Ge cell with a highly efficient filter-mirror can be 28% for AM2 spectral distribution with a concentration of 125. The projected conversion efficiency of a two-cell system using Si and a material having a band gap energy in the vicinity of 1.75 eV is expected to be 31% or higher. An important feature of this beam-splitting method is a significant reduction in the internal energy losses in each cell over corresponding losses occurring in a single cell under the same illumination. Consequently, this method is particularly suited to operation with concentrated solar irradiation. (Author)

A79-41025 Multigap solar cell requirements and the performance of AlGaAs and Si cells in concentrated sunlight. R. L. Moon, L. W. James, H. A. Vander Plas, T. O. Yep, G. A. Antypas,

and Y. Chai (Varian Associates, Palo Alto, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. (A79-40881 17-44) New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 859-867. 19 refs. U.S. Department of Energy Contract No. 07-6953; Contract No. EY-76-C-03-1250.

Multigap solar cells are capable of operating in concentrated sunlight with efficiencies of greater than 30%. If only two bandgaps are considered, their optimum values are 1.1 eV and 1.65 eV. Within this energy range Si and Al-Ga-column V alloys are possible materials and their relative merits are discussed. Experimentally, $\text{Al}(x)\text{Ga}(1-x)\text{As}$ for x less than 0.24 and Si have been tested individually and in combination with a spectral splitting filter. In combination a total efficiency of 28.5% including the filter has been observed at 165 AM 1.23 suns. For an ideal filter this corresponds to 31% combined cell efficiency. (Author)

A79-41026

Analysis of multiple-cell concentrator/photovoltaic systems. A. Bennett and L. C. Olsen (Joint Center for Graduate Study, Richland, Wash.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 868-873. 6 refs.

An analytical study of the multiple cell concentrator photovoltaic system has been conducted. Overall system efficiencies are determined for both ideal and real systems using conventional photovoltaic models and existing experimental parameters. The study shows that the efficiencies of 3-cell and 6-cell systems will be 50% and 60%, respectively when illuminated by an AM1 spectrum at 1000 suns. Under the same conditions a 2-cell system will be 44% efficient. Calculations for a 2-cell system based on a realistic silicon cell and an ideal high band gap device indicate that an efficiency of 28% is possible. Studies of 2-cell and 3-cell systems utilizing a realistic GaAs cell predict possible efficiencies of 35% and 39%, respectively. (Author)

A79-41027

Two-junction cascade solar cell characteristics under 1000 concentration ratio and AM 0-AM 5 spectral conditions. M. F. Lamorte and D. Abbott (Research Triangle Institute, Research Triangle Park, N.C.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 874-880. 7 refs. Contract No. F33615-76-C-1283.

It has been shown from first principles, using the integral form of the transport equations, that the efficiency of a two-junction AlGaAs-GaInAs cascade solar cell optimized at 290 K and under AM 0 spectral conditions may exceed 30%. Further studies of this cascade structure have been carried out to determine performance under AM 0 to AM 5 spectral conditions and at a concentration ratio of 1000 over the temperature range 290 to 600 K. In addition, the two-junction AlGaAs-GaInAs cascade cell has been optimized at 290 K and under AM 1.5 spectral conditions. The performance characteristics of the designs optimized under AM 0 and AM 1.5 conditions are compared over the temperature range 290 to 600 K. The AM 0 optimized structure was used as the initial structure to determine the optimized structure under AM 1.5 spectral conditions. The results of the computer modeling show that the optimized wide bandgap cell parameters under AM 0 and AM 1.5 are somewhat different. However, the optimized narrow bandgap cell parameters are identical for AM 0 and AM 1.5. The theoretical efficiency at 290 K increases with increasing concentration ratio, approaching 40% at 1000 concentration ratio. (Author)

A79-41028

Spectrally split tandem cell converter studies. J. A. Cape, J. S. Harris, Jr., and R. Sahai (Rockwell International Science Center, Thousand Oaks, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 881-885.

Two-cell tandem converter schemes in which the solar spectrum is split by a dichroic mirror were studied. The purpose of this study

was to compare the experimental results obtained using existing cells and mirrors, with predictions based on a lumped series resistance modeling scheme. The calculated efficiencies are presented as a function of concentration for: (1) present design GaAs concentrator cell and a commercial Si cell, (2) for a new design GaAs cell with reduced series resistance and the Si cell, and (3) for the new GaAs cell and a hypothetical GaSb cell. The latter combination exceeds 30% efficiency. Measurements made at 340 suns and 800 suns using the present cells and an off-the-shelf dichroic mirror with a cutoff at 0.73 micron yield efficiencies in good agreement with the model calculations. (Author)

A79-41029

Design of high efficiency monolithic stacked multijunction solar cells. L. M. Fraas and R. C. Knechtli (Hughes Research Laboratories, Malibu, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 886-891. 18 refs.

Monolithic multijunction solar cells made of lattice matched semiconductor materials and their efficiency and fabrication procedures are described. AlGaAs/GaAs/Ge dual junction cells made monolithically by epitaxial deposition of GaAs and Ge layers produce two photo-voltaically-active junctions, with nearly equal short circuit current available to the two junctions under space (AMO) illumination, permitting efficient operation of both junctions in a series connection. The current distribution in the active cell junctions and the operating voltages are computed, noting the efficiency of 25.6% for the AlGaAs/GaAs/Ge dual junction cell for space applications, and 40.4% for the $\text{CdZnS/InGaP/GaInAs/Ge}$ three junction cell for terrestrial applications. Two low temperature growth technologies, molecular beam epitaxy (MBE) and low pressure chemical vapor deposition (CVD) are described, noting that the AlGaAs/GaAs cell is not expected to degrade as a result of the Ge layer growth. A.T.

A79-41030

Concepts for rheotaxially-grown thin-film tandem III-V solar cells. A. G. Milnes (Carnegie-Mellon University, Pittsburgh, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 892-897. 22 refs.

The concept of two solar cells in optical series is discussed with reference to thin-film cells grown by rheotaxial methods. In the rheotaxy process the desired solar cell is grown on a molten intermediate layer that buffers it from the substrate and so allows large grain crystals to develop. The cell that faces the sun must have a substrate and rheotaxial layer capable of transmitting unused radiation to the underlying cell. Suitable semiconductor rheotaxy layers based on sulfur and selenium glasses are identified for use with dual cell structures of III-V semiconductors. Growth processes are suggested and structures are proposed for dual cells that have the potential of being 25 to 30% in efficiency. Rheotaxy concepts are also considered for tandem solar cells of II-IV-V₂ compound semiconductors. (Author)

A79-41031

Investigation of potentially high efficiency photovoltaic cells consisting of two heterojunctions on a common wide band gap semiconductor base. M. Arienzo and J. J. Loferski (Brown University, Providence, R.I.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 898-903. 9 refs. NSF-supported research.

A79-41032 *

Product pricing in the Solar Array Manufacturing Industry - An executive summary of SAMICS. R. G. Chamberlain (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 904-907. 11 refs.

Capabilities, methodology, and a description of input data to the Solar Array Manufacturing Industry Costing Standards (SAMICS) are presented. SAMICS were developed to provide a standardized procedure and data base for comparing manufacturing processes of Low-cost Solar Array (LSA) subcontractors, guide the setting of research priorities, and assess the progress of LSA toward its hundred-fold cost reduction goal. SAMICS can be used to estimate the manufacturing costs and product prices and determine the impact of inflation, taxes, and interest rates, but it is limited by its ignoring the effects of the market supply and demand and an assumption that all factories operate in a production line mode. The SAMICS methodology defines the industry structure, hypothetical supplier companies, and manufacturing processes and maintains a body of standardized data which is used to compute the final product price. The input data includes the product description, the process characteristics, the equipment cost factors, and production data for the preparation of detailed cost estimates. Activities validating that SAMICS produced realistic price estimates and cost breakdowns are described. A.T.

A79-41033 Analysis and simulation of the energy source of the future - The solar breeder. M. Wihl and A. Scheinine (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 908-910. 5 refs.

The basic principles of the solar breeder system were analyzed by examining its total energy balance. The solar breeder is an energy self-sufficient industrial manufacturing plant that produces net energy in the form of solar electrical panels. Direct energies in the form of utility electricity and indirect energies used in the making of breeder system materials and equipment were considered. An energy gain formula related the net energy obtainable during the first panel lifetime cycle of breeder operation to the fossil energy expended in the breeder construction, and showed that the breeder has the potential of delivering its inverted energy many times during its first cycle. It is concluded that the breeder systems approach will allow an evaluation of solar to electrical energy conversion and provide information on their large scale realization. A.T.

A79-41034 Cost criterion for low efficiency solar cells to make system power cost competitive with that of high efficiency cells. D. Redfield (RCA Laboratories, Princeton, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 911-913.

A79-41035 Model for comparing cost of flat-array and concentrator photovoltaic solar-cell systems. A. S. Roy. In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 914-919. 51 refs. Contract No. W-7405-eng-26.

The flat-array and the concentrator solar-cell systems represent distinctly different design concepts leading to distinctly different goals for cell development. A simplified model is formulated which helps to assess and compare the different design concepts, based on dividing all the cost-components of a solar system into two major categories. One is the area-related subsystem (array structures or concentrators, wiring, piping, installation, etc.), and the other is the converter subsystem, the cells. The great significance of the non-cell cost-components is related to their 'learning curve' which seems to be not as steep as that of the cell cost. Fitting cost functions to presently available cost data indicates that by using the concentrator concept high-efficiency cells may yield relatively cost-effective systems, even if the cells cost more (by several orders of magnitude) than low-efficiency cells used with the flat-array concept. This should have a significant effect on the definition of photovoltaic research goals. (Author)

A79-41036 Terrestrial concentrating photovoltaic systems comparative performance and costs. R. C. Hamilton and C. E. Witt (PRC Energy Analysis Co., McLean, Va.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 920-924. 7 refs.

A study to determine if the cost and effectiveness of photovoltaic and hybrid photovoltaic/thermal systems can be increased through optimum design, improved materials, and production cost reduction so that they are competitive with oil and natural gas in various regions of the U.S. is presented. Steps including estimates of solar cell costs, selection of the most cost-effective design, and consideration of future solar system costs and efficiencies are listed, emphasizing solar concentrator hybrid photovoltaic thermal systems. Geographical areas, cost assumptions and alternate concentrating photovoltaic systems, including solar insolation, collector types, and tracking are discussed. It is concluded that higher concentration ratios justify higher efficiency cells at higher costs, concentration ratios greater than 50 to 100 do not increase the net user value of energy per kWh for 20% cells, and that hybrid systems are economically desirable where individual photovoltaic electric or thermal solar systems are not viable. A.T.

A79-41037 * Lifetime Cost and Performance model for photovoltaic power systems. C. S. Borden (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 925-929.

This paper describes the approach and procedures of the Lifetime Cost and Performance (LCP) model for photovoltaic power systems. The LCP model is designed to evaluate the impact of alternative initial design and recurrent policy decisions on both cost and power output over the lifetime of a photovoltaic power plant. LCP is, therefore, useful to system designers and operators for addressing questions relating to optimal system configuration, installation activities, level of effort and timing of operations/maintenance actions, allowable degradation and replacement options. (Author)

A79-41038 Performance of AlGaAs/GaAs terrestrial concentrator solar cells. H. A. Vander Plas, L. W. James, R. L. Moon, and N. J. Nelson (Varian Associates Corporate Solid State Laboratory, Palo Alto, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 934-940. 12 refs. U.S. Department of Energy Contract No. 05-4413.

A device modeling program was used to design a front contact grid that allows realization of high efficiencies at 1000 sun illumination, and predicts an AM2 conversion efficiency of 23.8% at 50 C for a 10.9 W/cell output with a flux concentration of 1000. The experimental work identified the minority carrier diffusion lengths and the specific contact resistance as the most critical processing parameters, and verified the accuracy of the computer model. A number of AlGaAs/GaAs solar cells with conversion efficiencies greater than 21% at approximate AM 1.5 flux concentrations of 1000X were fabricated. The best of these had an AM 1.53 maximum power of 10.7 W at a flux concentration of 945, and two cells had efficiencies greater than 23%, the value equal within experimental error to the predicted efficiency, and greater than the maximum 19% reported for vapor deposited AlGaAs/GaAs solar cells. A.T.

A79-41039 GaAs solar cells for high solar concentration applications. J. Ewan, R. C. Knechtli, R. Loo, and G. S. Kamath (Hughes Research Laboratories, Malibu, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 941-945. U.S. Department of Energy Contract No. 05-0164.

Large-area GaAs solar cells capable of operating efficiently at high solar concentrations have been fabricated at Hughes Research Laboratories (HRL). The cells have an active area of 1 sq cm and were designed specifically for operation at solar constants on the order of 1000 suns. They are fabricated using a modified infinite melt liquid phase epitaxy technique developed at HRL. The technique was used to grow the (AlGa)As layer and to form the active p-n junction. The depth of the p-n junction, which is an important cell parameter, should not be much less than 1 micron below the (AlGa)As-GaAs heterojunction. Cells with 1 sq cm active areas and fabricated with the above technique have resulted in power outputs of not less than 20 W at 1000 suns. For an AM 1 spectrum, these cells have an efficiency of 20% at 1000:1 concentration ratios. (Author)

A79-41040 High efficiency AlGaAs/GaAs concentrator solar development. R. Sahai, D. D. Edwall, and J. S. Harris, Jr. (Rockwell International Science Center, Thousand Oaks, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 946-952. 9 refs.

The development of GaAlAs/GaAs concentrator solar cells with an AM1 efficiency of 24.7% at 180 suns and approximately 50 C is reported. The cells utilize an ultrathin GaAlAs window layer to achieve high current collection efficiency at short wavelength and high short circuit current. Cell design is discussed, noting that the key parameter to maintain high cell efficiency at high illumination levels is cell series resistance. The front contact grid design is considered, including the effects of the illumination intensity profile and the sheet resistivity of the top layer, and efficient contact patterns for the circular and rectangular concentrator cells are illustrated. The new grid patterns will enable the extension of the thin window approach to 1000 suns. The cell fabrication involving the growing of the p-GaAs and p-GaAlAs layers at 750 C is described, noting the effect of the layer thickness and doping to yield low series resistance. The cell testing techniques are discussed, with the cell temperatures monitored for proper interpretation of the measured I-V characteristics. The cell measurement technique can be used to study the heat transfer process in cooling the cell. A.T.

A79-41041 High-efficiency GaAs shallow-homojunction solar cells. J. C. C. Fan and C. O. Bozler (MIT, Lexington, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 953-955. 7 refs. USAF-supported research.

Conversion efficiencies up to 20% at AM1 were obtained for GaAs shallow-homojunction single-crystal cells without Ga(1-x)Al(x)As layers. These devices use an n(+)/p/p(+) structure prepared by chemical vapor deposition (CVD) in which surface recombination losses are reduced because the n(+) layer is so thin that most of the carriers are generated in the p layer below the junction. The homojunction cells are fabricated by a simplified technique that does not use vacuum processing, with metallization done by electroplating, and the antireflection coating prepared by anodic oxidation of the n(+) layer. A.T.

A79-41042 Large area thin film gallium arsenide solar cells. S. S. Chu, T. L. Chu, and H. T. Yang (Southern Methodist University, Dallas, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 956-959. 5 refs. Contract No. EY-76-C-03-1284.

Thin films of gallium arsenide deposited on tungsten-coated graphite substrates were used for the fabrication of MOS type solar cells. Graphite was selected as a substrate but due to the high electrical resistance of the gallium arsenide/graphite interface, a tungsten interlayer was used to minimize the resistance. The preparation of the tungsten/graphite substrates and the deposition of

gallium arsenide films by the reaction of gallium, hydrogen chloride, and arsine in a hydrogen flow system are described. The deposited films were oxidized, coated with gold or silver barrier layers, and with a titanium dioxide antireflection coating. The current-voltage characteristics of solar cells were measured in the dark and under illumination with ELH quartz-halogen lamps calibrated with a standard silicon solar cell at AM1 conditions. Large area (9 sq cm) cells with AM1 efficiencies of 6.5% were reproducibly prepared, and it is believed that the conversion efficiency can be improved by optimizing the deposition and oxidation processes. A.T.

A79-41043 The properties of polycrystalline GaAs materials and devices for terrestrial photovoltaic energy conversion. P. D. Dapkus, R. D. Dupuis, R. D. Yingling, J. J. Yang, W. I. Simpson, L. A. Moudy, R. E. Johnson, A. G. Campbell, H. M. Manasevit, and R. P. Ruth (Rockwell International Corp., Anaheim, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 960-965. 10 refs.

The properties of polycrystalline GaAs materials and photovoltaic devices are described. The GaAs films were grown by metallorganic chemical vapor deposition. Efficiencies of 2.25% for uncoated Schottky barrier solar cells have been fabricated. Properties which limit device efficiencies are discussed. (Author)

A79-41044 Progress towards high efficiency polycrystalline thin-film GaAs AMOS solar cells. Y. C. M. Yeh, F. P. Ernest, and R. J. Stirn (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 966-971. Research supported by the U.S. Department of Energy and NASA.

Results of Ge film recrystallization using focused laser beams and GaAs film growth on such layers in the making of high efficiency thin-film AMOS solar cells are discussed. Since a conversion efficiency of 14% was obtained for an AMOS cell fabricated on sliced bulk polycrystalline GaAs, high efficiency cells are being developed by chemically vapor-depositing GaAs films on previously recrystallized evaporated Ge films to minimize the grain boundary (GB) effects. Schottky barrier solar cells made on sliced polycrystalline GaAs wafers were studied to investigate the effects of grain boundaries on cell properties and the potential efficiency of GaAs thin-film cells. Ge film recrystallization and the chemical vapor deposition (CVD) of the 2 to 3 micron thick GaAs films are described. AMOS solar cells with 100 Angstrom thick Ag metallization were made on CVD GaAs/recrystallized Ge/W substrates with an energy conversion efficiency of 8%. A.T.

A79-41045 Solar cells based on GaP(x)As(1-x) compounds. D. L. Barton and L. C. Olsen (Joint Center for Graduate Study, Richland, Wash.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 972-977. 10 refs.

Cells based on three GaP(x)As(1-x) compounds have been investigated for high band gap cells, namely GeP(0.4)As(0.6) (1.90 eV), GaP(0.65)As(0.35) (2.08 eV) GaP (2.25 eV). All cells are diffused p/n junctions formed by diffusing Zn into n-type epi-wafers. The best result to date was obtained with GeP(0.4)As(0.6). An efficiency of 5.3% was obtained under AM1.5 simulation. Efficiencies of 1.9% and 1.2% have been obtained for GaP(0.65)As(0.35) and GaP, respectively. The materials presently being used are normally made for LED applications. Thus, the two higher band gap materials have a 10 micron N-doped layer. Significantly improved spectral collection efficiencies have been obtained with cells having the N-layer removed by etching. Efficiencies of nearly 15% and 10% are projected for cells based on GeP(0.4)As(0.6) and GaP(0.65)As(0.35), respectively. Significant improvement in GaP solar cell efficiency will be difficult because of the indirect band gap and magnitude of the minority carrier diffusion length. (Author)

A79-41046 # A 60kW solar cell power system with peak power tracking and utility interface. D. J. Roesler (U.S. Army, Mobility Equipment Research and Development Command, Fort Belvoir, Va.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 978-983. Research supported by the U.S. Department of Energy.

This paper describes a 60 kW solar cell power system that features peak power tracking and an utility interface. The objective of this effort is to effectively augment a typical utility network with solar cell power and thereby reduce the fuel consumption of the utility power plant. The solar system will not utilize an on-site energy storage. It is planned to produce as much solar power as possible and to feed all the power to the utility. The 60 kW solar cell power system will be designed, fabricated and partially tested during the first eight months of 1978. At that time, this system will be one of the first attempts to actually connect a solar cell power system to an utility network and the findings of this project will have an important influence on future solar cell power systems. (Author)

A79-41047 * # An inverter/controller subsystem optimized for photovoltaic applications. R. L. Pickrell, W. C. Merrill (NASA, Lewis Research Center, Cleveland, Ohio), and G. O'Sullivan (Abacus Controls, Inc., Somerville, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 984-991. 5 refs.

Conversion of solar array dc power to ac power stimulated the specification, design, and simulation testing of an inverter/controller subsystem tailored to the photovoltaic power source characteristics. This paper discusses the optimization of the inverter/controller design as part of an overall Photovoltaic Power System (PPS) designed for maximum energy extraction from the solar array. The special design requirements for the inverter/controller include: (1) a power system controller (PSC) to control continuously the solar array operating point at the maximum power level based on variable solar insolation and cell temperatures; and (2) an inverter designed for high efficiency at rated load and low losses at light loadings to conserve energy. It must be capable of operating connected to the utility line at a level set by an external controller (PSC). (Author)

A79-41049 Maximum power trackers for photovoltaic arrays. E. E. Landsman (MIT, Lexington, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 996-1000. 6 refs. Research sponsored by the U.S. Department of Energy.

A maximum power point tracker can increase the time that a photovoltaic power system operates near the maximum power point of the solar array and this can increase the system energy output and enhance its economic value. A maximum power tracking system has been devised at MIT/Lincoln Laboratory which is conceptually simpler than presently available trackers and can be simply implemented with digital logic. It is based on the observation that maximum power into most loads corresponds with maximum voltage or current. This paper establishes the theoretical background and presents the results of breadboard testing. (Author)

A79-41050 Potential for stand-alone photovoltaic on-site total-energy residential systems. E. F. Federmann, W. Feduska, W. J. McAllister (Westinghouse Electric Corp. Pittsburgh, Pa.), and S. L. Nearhoof (Burt, Hill, Kosar, Rittleman, and Associates, Butler, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1004-1009.

The potential use of stand-alone solar energy systems to supply about 90% of the thermal energy and electricity required by single residences at sites in the major geographical regions of the United States (the Northeast, Southeast, Gulf Coast, Southwest, West, and

Great Lakes) was analyzed. The solar systems are considered to be supplemented by an on-site auxiliary system, typically a small (1.5 kW) engine-generator and a heat exchanger to the thermal water storage system. A computer simulation model providing an hourly record of all energy flows in a system categorized by source and usage was utilized. Systems were specified by the area and tilt of water-cooled and air-cooled collector arrays, efficiencies of the system and thermal characteristics of the residence. Average system costs for 1985/1990, 1990 and 2000 were calculated. The electrical and thermal energy requirements of residences at each of the sites were computed, together with the percentage of total energy needs supplied by solar systems and the average cost of oil for backup systems. Results indicate that autonomous solar residential systems are feasible for virtually all regions of the United States. C.K.D.

A79-41051 Solar photovoltaic intermediate power system operating strategies and economic considerations. P. F. Pittman and C. R. Chowanec (Westinghouse Electric Corp., Pittsburgh, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1010-1015. Contract No. E(11-2)-2744.

Applications of solar photovoltaic Intermediate Power Systems were studied ranging in peak power output from 100 kW to 10 MW. The two applications found most promising were a proprietor owned system serving a commercial load, and a small utility owned substation. Comparative cost/performance analyses were made for a system with a peak power output of 500 kW owned either by a proprietor or a utility. The proprietor owned system could obtain a discounted cash flow return on investment of 15% in 10 years if solar cells costing \$100/kW with an efficiency of 10% were used. The utility owned system, co-located with a battery load leveling plant, can attain a favorable cost/benefit ratio with solar cells of the same cost and efficiency. (Author)

A79-41052 Role of intermediate markets in P/V industry development. O. H. Merrill (Science Applications, Inc., Pasadena, Calif.), T. Jaras, M. R. Hamilton, J. S. Hauger, J. Isreal, K. W. Boras (BDM Corp. McLean, Va.), A. Clifford, and J. Conger (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1016-1020. 5 refs.

The role of intermediate markets in supporting development of the photovoltaic industry is examined. Problems in developing precise market potential and penetration rate estimates are discussed. The potential intermediate markets for photovoltaic street and highway lighting and low level water pumping units are considered. The advantages offered by each of these applications are given, major barriers to their development are identified, and technological innovations required are examined. C.K.D.

A79-41053 The diffusion of photovoltaics - Marketing and government policy implications for an emerging technology. G. L. Lilien and S. T. McCormick (MIT, Cambridge, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1021-1027.

From the background of classic innovation-diffusion models, a new model of photovoltaic marketplace diffusion is developed. The novelty of the model is that it predicts market response as a function of controllable variables, and can be calibrated by field measurements. Here, government investment strategy is the input variable, so the model can help predict optimal government allocation policies over sectors, regions and time. In addition, some developments in allocation theory under simple conditions are given. Using field measurements to calibrate the model, several hypothetical government policies are simulated. The sensitivity of the model to variations in its parameters is also explored. Finally, implications for government policy formulation are discussed, and directions for future expansion of these preliminary results are suggested. (Author)

A79-41054 Status of the DOE Photovoltaic Concentrator Technology Development Project. M. W. Edenburn, D. G. Schueler, and E. C. Boes (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1028-1039. 20 refs. Research supported by the U.S. Department of Energy.

A report on the progress of the DOE Photovoltaic Concentrator Technology Development Project, which has undertaken the development of low-cost photovoltaic devices, is presented. Test results obtained in three areas of interest, solar concentrators, concentrator array subsystems, and concentrator cell technology, are summarized, and five-year cost and efficiency targets for each of these areas are given. The performance and design characteristics of a variety of photovoltaic concentrators are presented. Cost data and specular reflectance properties of a wide range of mirror materials, including second-surface glass, metallized plastic films and polished, bulk aluminum, are reported, together with hail-test results and typical focal lengths of slope errors for model parabolas. C.K.D.

A79-41055 Design, technology and cost of Si cells for concentrator applications. V. Dalal (Delaware, University, Newark, Del.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1040-1045. 9 refs. Research supported by the U.S. Department of Energy.

The design of large area (more than 10 sq cm), high efficiency, low-cost Si solar cells for use under low to medium concentration (10-100 x) is discussed. Constraints imposed on the junction and grid technology, base layer characteristics, and anti-reflection surface for high-efficiency operation at these concentration levels are examined. Within the context of these constraints, it is concluded that both n and p based are acceptable for operation up to 50 suns; n-type bases are preferable beyond these concentrations. Junction formation by ion implantation is preferable to vapor phase diffusion, as diffused layers of low sheet resistance have low quantum efficiencies for short-wavelength photons. Ion implantation gives precise control of impurity profiles with dopant densities well below the solid-solubility limits. The optimum grid design for high intensity cells consists of rectangular grids with cross buss-bars, a structure limiting total Ohmic losses to about 15%. Textured anti-reflection surfaces are desirable as the effective absorption constant is increased by light trapping. C.K.D.

A79-41056 Fabrication experience with high efficiency silicon concentrator cells. S. Khemthong, P. A. Iles, S. Coclof, and K. S. Ling (Optical Coating Laboratory, Inc., City of Industry, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1046-1051. 10 refs.

The design and fabrication of high-efficiency silicon concentrator cells are discussed. Analytical procedures used to optimize the sheet resistance of the diffused layer, placement of grid fingers, and resistance of the gridlines themselves are outlined. An example of application of the design procedure to a simple case involving a network of parallel grid lines is presented. The fabrication of high-efficiency cells with conventional n + p configuration is described, and performance data for some large area (2.25 in diameter) concentrator cells at 28 and 55 C are given. C.K.D.

A79-41057 Large-area concentrator solar cells. J. Lindmayer and C. Y. Wrigley (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1052-1055. U.S. Department of Energy Contract No. 05-6391.

This paper reports on four types of large-area cells manufactured by Solarex for application in concentrated sunlight. Two of these cell types are for operation at 50X to 100X concentration and are being developed for manufacture under contract to Sandia Laboratories. Another is for the Mississippi County Community College photovoltaic power system, to be operated at an average 20X concentration. The fourth type is the Solarex type 25X20A 5cm x 5cm cell offered commercially for general application in concentrated sunlight at 20X. Measured performance is reported for 25 C operation.

(Author)

A79-41058 Reliability analysis of contracts to silicon solar cells for use in concentrated sunlight. B. Selikson and R. Mickelsen (Boeing Aerospace Co., Seattle, Wash.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1056-1060. 31 refs.

Possible mechanisms leading to degradation and failure of silicon solar cells with titanium-palladium-silver contacts during operation under illumination levels of 100 suns or more are examined. On the basis of data previously reported in the literature, it is argued that solid state interdiffusion produces Kirkendall voids, resulting in local contact lifting from the silicon. In addition, the high electron current densities produced under concentrated sunlight and the attendant temperature rise in the conductors could be expected to lead to electromigration failures, an effect which would be aggravated by the presence of Kirkendall voids in or under the contacts. C.K.D.

A79-41059 The effect of solar cell parameter variation on array power output. J. L. Watkins and E. L. Burgess (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1061-1066. Research supported by the U.S. Department of Energy.

Array maximum power is affected by variations in cell series resistance, cell photon generated current, and cell temperature. These parameters were considered independent and the effect of their variation on array performance was investigated using a combination of analysis techniques and a computer circuit simulation program, SPICE. Results indicate that for series connected arrays, variations around a mean of cell series resistance and cell operating temperature insignificantly affect array maximum power. However, variations in cell photon generated current significantly affects power output as array current is limited by the weakest cell. Universal curves are presented which allow these results to be applied to a variety of arrays. (Author)

A79-41060 * Photovoltaic design optimization for terrestrial applications. R. G. Ross, Jr. (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1067-1073.

As part of the Jet Propulsion Laboratory's Low-Cost Solar Array Project, a comprehensive program of module cost-optimization has been carried out. The objective of these studies has been to define means of reducing the cost and improving the utility and reliability of photovoltaic modules for the broad spectrum of terrestrial applications. This paper describes one of the methods being used for module optimization, including the derivation of specific equations which allow the optimization of various module design features. The method is based on minimizing the life-cycle cost of energy for the complete system. Comparison of the life-cycle energy cost with the marginal cost of energy each year allows the logical plant lifetime to be determined. The equations derived allow the explicit inclusion of design parameters such as tracking, site variability, and module degradation with time. An example problem involving the selection of an optimum module glass substrate is presented. (Author)

A79-41061 A modified single diode model for high illumination solar cells for simulation work. R. T. Otterbein, D. L. Evans, and W. A. Facinelli (Arizona State University, Tempe, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1074-1079. 8 refs. U.S. Department of Energy Contract No. 05-6012.

The purpose of this work was to investigate the applicability of simple solar cell models for use in simulating the behavior of current state-of-the-art silicon solar cells designed for use with optical concentration. Approximately 60 I-V curves from a Spectrolab concentrator cell, and Solarex 20X, 40X, and two 100X cells were examined. The data extended over a temperature range of 20 C to 70 C and a concentration range of 1 sun (1000 W/sq m) to 100 suns. Attempts to reproduce these I-V curves through least squares fitting resulted in a single diode model with concentration dependent series resistances, concentration dependent diode imperfection factors, and concentration and temperature dependent reverse saturation currents. Series resistances were found to decrease rapidly as concentration increased and to level out to nearly constant values that were maintained from 20 to 100 suns. Diode imperfection factors took on values close to unity at one sun, and increased nearly linearly to values of 2.5 to 4 at 100 suns. (Author)

A79-41062 An experimental study of series combination of solar cells. R. Lahri, Y. A. Gnanainder, and T. K. Bhattacharya (Central Electronics, Ltd., Sahibabad, India). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1080-1083. Research supported by the Ministry of Industrial Development of India.

The characteristics of a series combination of solar cells depend critically on certain parameters of the constituent cells, such as the short circuit current, effective lumped series resistance, ideality factor etc., and the mismatch of these parameters amongst various constituents. A simple analysis is done to identify the relative importance of some of these parameters in the determination of the power output of the combination. Experimental results in support of the analysis are also presented to emphasize the effect of mismatch. (Author)

A79-41063 Fixed angle and seasonably adjustable structural support concepts for solar converters. P. S. Masser, M. C. Keeling, and I. A. Lesk (Motorola, Inc., Semiconductor Group, Phoenix, Ariz.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1084-1089. U.S. Department of Energy Contract No. 07-6984.

A survey of state-of-the-art support structures for small (residential), medium (commercial) and large (utility) scale solar arrays was conducted, and potential reductions in manufacturing, installation, and operating costs offered by different support configurations were analyzed. Truss, frame, gunite, concrete slab, inflatable and treated plywood support concepts were considered. In addition, concepts involving direct attachment to an existing structure or incorporation as an integral part of a structure were examined. Panel structural types included film, plate, plate plus mono-directional beams, plate plus bi-directional beams. Computer-generated parametric cost estimates for the truss and frame configuration are presented. C.K.D.

A79-41064 Poly- vs single-crystal silicon solar cells. A. B. Kuper (Case Western Reserve University, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1090-1095. 7 refs.

Purpose of these experiments was to identify effects of non-single crystalline structure on silicon solar cell performance. Pulled crystal (111) low-life-time, low-cost scrap ingot ends were used, of which about half of each was single, the other large-grained poly or twinned. Thus poly and single crystal cells could be cut from the same ingot and processed together for comparison. Annealing improved poly cell efficiency even though the electron diffusion length (10-40 microns) is less than the grain size 100-1000 microns. This suggests that principal effect of boundaries is to precipitate impurities. Electron diffusion length and short circuit current were highest in annealed twinned and columnar-grained poly. The open circuit voltage and fill-factor were highest in single because of their more perfect pn junctions. However, all these cells after anneal, except transverse-grained poly, had similar efficiency exceeding 9% AM1/AR-coated. (Author)

A79-41065 Characteristics of semicrystalline silicon solar cells. J. Lindmayer (Solarex Corp., Rockville, Md.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1096-1100.

Silicon ingots were prepared which had neither Czochralski nor float-zone crystal growth. These ingots were sliced into wafers for fabrication of silicon solar cells of either 2cm x 2cm or 5cm x 5cm sizes. These slices have crystallites of some few millimeters in size, ranging up to approximately half a centimeter. After being etched to remove sawing damage these slices were utilized for fabrication of solar cells. The solar cells constructed in this manner from the semi-crystalline silicon were characterized to determine their properties. These solar cells have ranged in power conversion efficiencies up to 16% at AM1 illumination. Data are presented herein on some of the characteristics of this new class of silicon solar cells. (Author)

A79-41066 Solar cells on R.A.D. polycrystalline silicon. E. Fabre, Y. Baudet, S. M. Ebeid (Laboratoires d'Electronique et de Physique Appliquée, Limeil-Brevannes, Val-de-Marne, France). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1101-1105. 19 refs. Research supported by the Délégation Générale à la Recherche Scientifique et Technique.

Solar cells have been made on polycrystalline silicon layers deposited onto a carbon substrate from the melt (Ribbon-Against-Drop process). Three different structures have been investigated for the collecting junction: the n(plus)/p homojunction, the M.I.S. metal-insulator-semiconductor barrier and the heterojunction with In2O3. The best conversion efficiency (6.9 percent) is measured with a n (plus)/p homojunction as obtained with a modified diffusion process. An elaborate model involving recombination at twins and grain boundaries is required to understand the temperature dependence and the non-linear behavior of such cells with illumination. (Author)

A79-41067 Thin film polycrystalline silicon solar cells. T. L. Chu, S. S. Chu, E. D. Stokes, C. L. Lin, and R. Abderrassoul (Southern Methodist University, Dallas, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1106-1110. 5 refs. Contract No. EY-76-C-03-1285.

Thin film polycrystalline silicon solar cells have been prepared by the deposition of a silicon film of 25-30 micron thickness containing a p-n junction on partially purified and recrystallized metallurgical silicon substrates. The dopant profile in the surface region of the solar cell was graded to provide a drift field, the substrate was of low resistivity to provide a back surface field, and vapor deposited tin dioxide was used as the antireflection coating. Solar cells were characterized by current-voltage, spectral response, and effective diffusion length measurements. At present, the best cells (9-10 sq cm area) have an AM1 efficiency of about 9.5% at room temperature. (Author)

A79-41068 * **Epitaxial solar cells on low-cost silicon substrates.** P. H. Robinson, R. V. D'Aiello, D. Richman, and B. W. Faughnan (RCA Laboratories, Princeton, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1111-1115. Research supported by the U.S. Department of Energy; Contract No. JPL-954817-78/1.

This work is directed toward a low-cost approach to the fabrication of silicon solar cells and combines the advantages and flexibility of the epitaxial technique with the use of potentially low-cost silicon substrates. Epitaxial graded base n/p/p+ solar cell structures were grown and evaluated on various forms of polycrystalline and metallurgical grade silicon as well as single crystal substrates. X-ray topographic techniques have shown improvements in the crystallographic quality of the layer grown on polycrystalline material. (Author)

A79-41069 **Performance of a one kilowatt concentrator photovoltaic array utilizing active cooling.** E. L. Burgess and D. A. Pritchard (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1121-1124. 5 refs. Research supported by the U.S. Department of Energy.

Operational experience on a 1-kW concentrating photovoltaic array incorporating silicon solar cells and Fresnel lenses is reported. The array was operated in two modes of active cooling. The first mode provides cell cooling by pumping water through tubes attached to the heatsink behind the solar cells. The array is also cooled in this mode by natural convection from both the front and back of the heatsink. The second mode of active cooling involves operating the array as a combined thermal/electrical system. In this combined thermal/electrical mode approximately 58% of the incident solar energy can be collected for thermal and electrical utilization. (Author)

A79-41070* **10 kW photovoltaic concentrator system design.** J. A. Castle and K. Ronney (Spectrolab, Inc., Sylmar, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1131-1138. U.S. Department of Energy Contract No. 05-45648.

The design and performance of a 10 kW photovoltaic concentrator is discussed. The concentrator system is made up of 40 identical 250 W concentrator units with two-stage optical concentration consisting of a linear parabolic trough and two compound elliptical secondary mirrors. The optics provide an overall effective clear aperture of 130 sq m. The units are ganged in parallel for elevation tracking and mounted on a carousel for azimuth tracking. Tracking is controlled by a solid state system which includes logic for nighttime return from west to east, off tracking in the event of overheating, and catch-up provisions to minimize loss of power generation after periods of low insolation. The system is passively cooled. The efficiency of a prototype unit expressed for an ambient temperature of 28 C is about 7.4%. The projected total system efficiency after slight modifications, primarily to the optics, is 8.6%, corresponding to a rated peak output of 11.15 kW under environmental test conditions. C.K.D.

A79-41071 **Project of the 'Ramón Areces' Concentrated Photovoltaic Power Station.** A. Luque, G. Sala, A. Alonso, J. M. Ruz, J. Fraile, G. L. Araújo, J. Sangrador, M. G. Agost, J. Eguren, and J. Sanz (Madrid, Universidad Politécnica, Madrid, Spain). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1139-1146. 22 refs. Research supported by the Ramón Areces Foundation.

A project for a Concentrated Photovoltaic Power Station consisting of a field of 16 arrays with two-axes tracking, a two-days battery of accumulators, a static inverter and a conventional fuel

motor generator set is described. This Power Station is intended to supply energy to a Spanish rural village of 240 inhabitants. A model for the global system is developed to permit a proper selection of its dimensions. An overall efficiency of 5.1 percent is to be expected. (Author)

A79-41072 **Combined photovoltaic thermal collector testing.** D. R. Smith, K. L. Biringer, and D. A. Pritchard (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1147-1152. Research supported by the U.S. Department of Energy.

A commercially available liquid-cooled thermal flat-plate collector was modified by the addition of 104 silicon cells in four parallel strings extending almost the entire length of the collector front surface. The electrical efficiency of the cell array was measured as a function of temperature for three different flow rates corresponding to temperature differences between inlet and outlet coolant ranging from 4 C to 38 C. The data showed a linear decrease in electrical efficiency with the temperature of the panel surface measured halfway between inlet and outlet ports. The efficiency-temperature relationship was independent of the temperature gradient. The thermal efficiency also exhibited a linear decrease with increasing difference between inlet coolant temperature and ambient temperature. The measured array efficiency (8.1 percent at 27 C) was comparable to the measured efficiency of a single cell from the same lot. (Author)

A79-41073 **Combined photovoltaic and thermal hybrid collector systems.** E. C. Kern, Jr. and M. C. Russell (MIT, Lexington, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1153-1157. 6 refs. Research sponsored by the U.S. Department of Energy.

A program for the development of hybrid solar energy collectors which convert solar radiation into a balance of low-grade thermal energy and direct-current electricity, is discussed. The program entails development and performance testing of hybrid collectors, performance modelling, a retrofit experiment with separate thermal and photovoltaic collectors, and economic analysis. The performance of five hybrid heating and cooling systems has been modelled for office building and residential applications in Phoenix, Arizona, Miami, Florida, Boston, Massachusetts, and Fort Worth, Texas. The systems considered include a baseline solar heating system, a parallel heat pump system, a series heat pump system, an absorption-cycle chiller, and a high-performance series advanced heat pump. A cost analysis has also been carried out to identify systems with optimum economics. Results show that greatest potential energy savings in all four geographical regions are offered by an advanced heat pump system. C.K.D.

A79-41074 **Performance tests of organic dyes in a planar solar concentrator with ribbon photovoltaic cells.** J. R. Wood and J. F. Long (Mobil Tyco Solar Energy Corp., Waltham, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1158, 1159.

A79-41075 **Status of the DOE Photovoltaic Systems Engineering and Analysis Project.** G. J. Jones and D. G. Schueler (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1160-1165. 15 refs. Research supported by the U.S. Department of Energy.

The economic viability of photovoltaic power systems depends not only on the reduction of photovoltaic array prices but also on the realization of acceptable total installed system price. The allowable total installed system price is calculated for various major application sectors, based on a range of projected levelized energy costs. These allowable prices are then compared to projected prices which are obtained by examining the current and future expected prices of the major subsystems comprising an operational system. Based on this comparison an assessment of the status of the major subsystem technologies, exclusive of the photovoltaic array, is given and areas requiring emphasis are identified. (Author)

A79-41076 Optimization of terrestrial photovoltaic power systems. J. K. Linn (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1166-1170.

Optimization of terrestrial photovoltaic (PV) power systems implies the identification and selection of system components which minimize the overall cost of power. The methodology, techniques, and some results are discussed for optimization of PV subsystem design tradeoffs. Included are (1) methods of orientation for flat plates and concentrating collectors, (2) collector type, (3) power conditioning sizing, (4) electrical energy storage sizing, and (5) operation temperatures. The optimal system type, component size(s) and resulting power costs are shown to be extremely dependent upon geographical location, PV cell costs, individual load characteristics, and component performance values. (Author)

A79-41077 Regional analysis of residential photovoltaic system concepts. A. S. Kirpich, E. J. Buerger, T. S. Chan, R. P. Fogaroli, G. P. O'Brien (General Electric Co., Space Div., Valley Forge, Pa.), and G. F. Tully (Massdesign Architects and Planners, Inc., Cambridge, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1171-1178. U.S. Department of Energy Contract No. 05-6177.

Conceptual designs of photovoltaic (PV) systems have been prepared for residences which reflect floor areas, architectural styles and energy conservation features applicable to median-income families in various regions of the United States during the coming decade. Detached and multifamily units are being considered. Roof-mounted PV arrays are being studied in conjunction with solar thermal collection systems which provide heat for space conditioning and domestic hot water. The attractiveness of these system options is being assessed in terms of economic competitiveness for twelve designated regions of the U.S. representing a broad spectrum of climatic characteristics. Performance analyses are being conducted for each design option using hourly weather data from SOLMET tapes for a representative site within each region. (Author)

A79-41078 Analysis of photovoltaic total energy system concepts for single-family residential applications. V. Chobotov and B. Siegel (Aerospace Corp., El Segundo, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1179-1184. Contract No. EY-77-C-03-1101.

The paper describes procedures for evaluating the performance and cost of photovoltaic total energy systems (PTES) and their application to the analysis of three PTES concepts designed to meet the thermal and electrical demands of typical single family houses in Phoenix, Arizona and Madison, Wisconsin. The three PTES concepts use: (1) solar arrays only, (2) separate thermal and photovoltaic panels, and (3) combined thermal/electric panels. The minimum levelized annual cost to the homeowner is determined as a function of photovoltaic array cost. Optimum panel areas and storage capacities are obtained for different energy backup costs and capital recovery factors for each of the system concepts. B.J.

A79-41079 Energy storage operation of combined photovoltaic/battery plants in utility networks. C. R. Chowanec, J. L. Maitlen, H. S. Kirschbaum, and W. Feduska (Westinghouse Electric Corp., Pittsburgh, Pa.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1185-1189. NSF Grant No. C-75-22180.

This paper summarizes the results of a study which investigated the operation of combined photovoltaic/battery systems in a total utility system context. The analysis made use of the conventional economic dispatching philosophy used in planning the day-to-day operation of utility systems. According to this approach, the battery storage element is charged when the utility system cost of generating power is lowest and discharged when it is highest. As a result, much of the energy placed in storage is from the utility network and only a portion is supplied by the photovoltaic element of the plant. Also, if the cost of generation dictates, the energy in storage may be dispatched at the same time as the photovoltaic plant. The rationale for this optimum operating scheme is discussed. (Author)

A79-41080 Central station power plant applications for photovoltaic solar energy conversion. S. L. Leonard (Aerospace Corp., El Segundo, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1190-1195. Contract No. EY-77-C-03-1101.

Previously reported technical and economic analyses of utility (central station power plant) applications for photovoltaic solar energy conversion have been extended to take into account (1) the use of concentrator systems, (2) operation in many parts of the U.S., (3) effects of recent revisions of the insolation data base, and (4) regional variations in the cost of fossil fuel. It is tentatively concluded that flat-plate photovoltaic plants with \$100-300/kWpk arrays will probably be economically competitive in most parts of the U.S. by the year 2000 but that systems with high or medium concentration will require that most of the thermal energy be used profitably in order to be competitive anywhere in the U.S. prior to the 2000 time period. (Author)

A79-41081 * Effects of design on cost of flat-plate solar photovoltaic arrays for terrestrial central station power applications. P. Tsou (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.) and W. Stolte (Bechtel National, Inc., San Francisco, Calif.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1196-1201. 8 refs. Contract No. NAS7-100.

The paper examines the impact of module and array designs on the balance-of-plant costs for flat-plate terrestrial central station power applications. Consideration is given to the following types of arrays: horizontal, tandem, augmented, tilt adjusted, and E-W tracking. The life-cycle cost of a 20-year plant life serves as the costing criteria for making design and cost tradeoffs. A tailored code of accounts is developed for determining consistent photovoltaic power plant costs and providing credible photovoltaic system cost baselines for flat-plate module and array designs by costing several varying array design approaches. B.J.

A79-41082 Defect free very shallow p+/n junction and associated photovoltaic effect. M. S. Bae (RCA Solid State Technology Center, Somerville, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1202-1207. 12 refs.

A boron diffusion process is described for the fabrication of a p(+) layer with a very high surface concentration. The characteristics of p(+)/n solar cells fabricated using this diffusion process in single crystal (CZ) silicon wafers are presented. Efficiencies of 14-17% were reproducibly achieved with fill factors ranging from 0.75 to 0.80. The measured quantum efficiency showed good blue response for the

shallow (0.15 micron) junction cases. Minority carrier lifetimes in the base region were 22-60 microsec, resulting in excellent collection efficiency at long wavelengths. B.J.

A79-41083 Effects of laser irradiation on a diffused layer in silicon. R. T. Young, J. Narayan, C. W. White, J. W. Cleland, W. H. Christie, and R. F. Wood (Oak Ridge National Laboratory, Oak Ridge, Tenn.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1208-1212. Contract No. W-7405-eng-26.

High-temperature diffusion of boron or phosphorus into silicon leads to the formation of precipitates and/or dislocation loops in the diffused layer, which influence junction characteristics and limit the photovoltaic current and voltage response. It is shown that dislocation loops can be removed, precipitates can be dissolved, and the boron or phosphorus in them can be electrically activated by high-power ruby laser radiation. This serves to reduce the sheet resistance and improve the junction characteristics as well as the solar cell parameters. B.J.

A79-41084 * Response of defects to illumination in silicon solar cells. C. V. Hari Rao, R. O. Bell, M. C. Cretella, J. C. Ho, F. V. Wald, and K. V. Ravi (Mobil Tyco Solar Energy Corp., Waltham, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1213-1219. 8 refs. Contract No. NAS7-100.

The enhancement of diffusion length with intensity was examined using spectral response measurements in solar cells based on Silso silicon and EFG silicon ribbon. Local diffusion length variations at defect sites were investigated as a function of illumination level using a scanning electron microscope operated in the electron beam induced current mode. An increase of diffusion length was observed at defect sites as the intensity level was increased. The diffusion length improvements are explained on the basis of saturation of minority carrier traps in these materials. The trap distribution in Silso silicon is shown to be peaked near (Ec - 0.7)eV. EFG silicon ribbon shows a broad, Gaussian distribution of traps located near (Ec - 0.5)eV. (Author)

A79-41086 Detection of processing- and radiation-induced defects in solar cells by transient capacitance spectroscopy. P. J. Drevinsky, J. T. Schott, H. M. DeAngelis (USAF, Rome Air Development Center, Bedford, Mass.), A. R. Kirkpatrick, and J. A. Minnucci (Spire Corp., Bedford, Mass.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1232-1237. 8 refs.

A transient capacitance technique was used to detect processing- and radiation-induced defects in silicon solar cells fabricated with implanted junctions and annealed by either pulsed electron beam processing or by furnace treatment. Comparison was made with diffused junction cells. A carbon-related defect was detected in as-fabricated implanted, electron beam annealed cells. Transient capacitance spectra of electron-irradiated cells show this defect in the three types of cells as well as a boron-related minority carrier trap and the divacancy. Cell characteristics were measured. (Author)

A79-41089 * # Design and fabrication of a photovoltaic power system for the Papago Indian Village of Schuchuli/Gunsight/, Arizona. W. J. Bifano, A. F. Ratajczak, and W. J. Ice (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1262-1267.

A79-41090 Design of the Natural Bridges National Monument 100 kW PV power system. E. F. Lyon, L. L. Bucciarelli, and A. E. Benoit (MIT, Lexington, Mass.). In: Photovoltaic Specialists

Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1268-1271. Research sponsored by the U.S. Department of Energy.

MIT/Lincoln Laboratory will manage the design, fabrication, installation, and testing of a 100 kW peak photovoltaic (PV) power system for the Natural Bridges National Monument in Utah. This system, scheduled to become operational in mid-1979, will convert sunlight into dc electrical power, store all or part of the accumulated energy in a large battery bank, and supply ac power to the NBNM site through the use of a main inverter. It is expected that the site demand will run from 10 to 40 kW. B.J.

A79-41091 * # Description and status of NASA-LeRC/DOE photovoltaic applications systems experiments. A. F. Ratajczak (NASA, Lewis Research Center, Cleveland, Ohio). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1272-1277. Contract No. E(49-26)-1022.

In its role of supporting the DOE Photovoltaic Program, the NASA-Lewis Research Center has designed, fabricated and installed 16 geographically dispersed photovoltaic systems. These systems are powering a refrigerator, highway warning sign, forest lookout towers, remote weather stations, a water chiller at a visitor center, and insect survey traps. Each of these systems is described in terms of load requirements, solar array and battery size, and instrumentation and controls. Operational experience is described and present status is given for each system. The P/V power systems have proven to be highly reliable with almost no problems with modules and very few problems overall. (Author)

A79-41092 Thin tandem junction solar cell. S.-Y. Chiang, B. G. Carbaja, and G. F. Wakefield (Texas Instruments, Inc., Dallas, Tex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1290-1293. 6 refs. Research sponsored by the U.S. Department of Energy.

The thin tandem junction cell (TTJC) has junctions on both the illuminated and most of the nonilluminated sides (n+/pn+/+ structure). The photoresponse I-V performance of cells was measured in two modes, with either collection from junctions on both sides or collection from only the nonilluminated side. The open n(+)/p junction eliminates the front surface recombination by confining light-generated carriers in the base region. For the back collection mode the carrier confinement can also be achieved with a p(+)/p front junction. B.J.

A79-41093 Development of high-efficiency p(+)-n-n(+)/back-surface-field silicon solar cells. J. G. Fossum, R. D. Nasby, and E. L. Burgess (Sandia Laboratories, Albuquerque, N. Mex.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1294-1299. 11 refs. Research supported by the U.S. Department of Energy.

The design and fabrication of high-efficiency p(+)-n-n(+)/back-surface-field (BSF) silicon solar cells are described. The technological development of the cells has been advanced by an analytical study of the pertinent device physics. This study has provided the identification and characterization of the primary physical mechanisms that can limit the solar cell performance, and has henceforth led to near-optimum BSF cell designs. Power-conversion efficiencies of nearly 17% at AM1 and greater than 18% at illuminations near 50 suns have been measured at 27 C. The cell fabrication process is straightforward and is characterized by exceptionally high yield. (Author)

A79-41094 * Design considerations for silicon HLE solar cells. F. A. Lindholm, A. Neugroschel, S. C. Pao (Florida University, Gainesville, Fla.), J. G. Fossum (Sandia Laboratories, Albuquerque,

N. Mex.), and C. T. Sah (Illinois, University, Urbana, Ill.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1300-1305. 23 refs. Research sponsored by the U.S. Department of Energy and NASA.

The high-low (H-L) junction in the emitter region that defines the high-low-junction emitter (HLE) solar cell suppresses the dark emitter recombination current $J_{sub E}$ so that the base recombination current dominates in determining the open-circuit voltage. For silicon cells this enables the achievement of considerably larger values of open-circuit voltage than those achievable in conventional structures. This paper describes experiments that demonstrate the achievement of $J_{sub E}$ suppression (to less than 5×10 to the -14th A/sq cm) and large open-circuit voltage (640 mV) in HLE test cells of two distinct types. In the first type (the diffused HLE structure) impurity diffusion forms the H-L junction in the emitter; in the second type (the oxide-charge-induced HLE structure) the H-L junction is formed in emitter material of relatively low doping concentration by an oxide-charge-induced electron accumulation layer. B.J.

A79-41100 Schottky effect and photovoltaic devices on the texturized surfaces. M. S. Bae (RCA Solid State Technology Center, Somerville, N.J.). In: Photovoltaic Specialists Conference, 13th, Washington, D.C., June 5-8, 1978, Conference Record. New York, Institute of Electrical and Electronics Engineers, Inc., 1978, p. 1337-1341.

Schottky barrier diodes and Schottky photovoltaic devices were fabricated on texturized surfaces and their electrical properties were measured. It is shown that rectifying gold contacts to such n type silicon surfaces are nonideal with high n values and low barrier heights, but that they can be made to approach the near ideal case by low temperature heat treatment in combination with further chemical polishing to remove sharp structural peaks and valleys. Functional solar cells were fabricated with fill factor of 0.6 and efficiency of 3.2% without AR coating. (Author)

A79-41125 Estimating heat loss in residential structures using aerial infrared imagery. E. Hoyer and K. S. Shanmugam (Wichita State University, Wichita, Kan.). In: Annual Asilomar Conference on Circuits, Systems, and Computers, 12th, Pacific Grove, Calif., November 6-8, 1978, Conference Record.

New York, Institute of Electrical and Electronics Engineers, Inc., 1979, p. 324-328.

The measurement of heat energy lost through the roof of residential and commercial buildings is becoming more important. This paper describes one method of obtaining this information: aerial infrared imagery. A description is given of the equipment used and the general background of the theory of infrared images is presented. Predominant causes of heat loss in residential buildings is given along with the observable result. A method of visual analysis of these thermograms is then presented along with a proposed method of correlation of these images with R-values for insulation. (Author)

A79-41154 Gaseous, particulate, and smoke emissions from a heavy duty automotive gas turbine engine. T. Shih, G. Smith, and G. Springer (Michigan, University, Ann Arbor, Mich.). *Environmental Science and Technology*, vol. 13, July 1979, p. 855-859. 29 refs. Research supported by the Ford Motor Co.

Gaseous, particulate, and smoke emissions were studied in the exhaust of a heavy duty automotive gas turbine engine. The effects of brake horsepower, gasifier rotor angular speed, overall mass air-fuel ratio, and combustor exit temperature were evaluated at engine loads ranging from 136 to 542 N-m and at constant output shaft angular speeds ranging from 1500 to 2700 rpm. The results were compared to emissions previously reported for a heavy duty spark ignition engine and a heavy duty compression ignition engine, both of which had platinum oxidation catalysts and EGR. The

hydrocarbon emissions from the gas turbine engine were lower, while the NO_x and CO emissions were comparable to the emissions from the spark and the compression ignition engines. Under all test conditions, the amount of particulate matter emitted was less than 0.001 g per bhp per hr (bhp is brake horsepower), and the smoke opacity of the exhaust gas was less than 0.3 Bosch unit. The brake specific fuel consumption of the gas turbine engine was also measured and was 40-50% higher than the consumption of a heavy duty spark and a heavy duty compression ignition engine operating at corresponding conditions. (Author)

A79-41208 Satellite power for the 1980s. D. Velupillai. *Flight International*, vol. 115, June 9, 1979, p. 2053-2056.

The uses of solar arrays, as a means of electrical power for spacecrafts, are studied with attention given to the concept of direct broadcast satellites. Restrictions of the Space Shuttle, (limited to 7-day missions due to fuel cell energy) are discussed and two basic types of solar arrays and their uses are then investigated in detail. In addition, solutions to the problem of launch-damaged arrays are presented and in this concept the solar array is partly deployed, unfolding only when final orbit is reached. Particular consideration is given to the construction of silicon solar cells. Radiation damage is found to be an important factor in solar array design because, depending on the orbit, an array can lose 1/4 of its output over a decade. It is concluded that an array must be designed with more power than needed so that the satellite lifetime is prolonged. Development in solar cell technology is presented and the advantages and disadvantages of different-sized cells are investigated. Finally, the concept of solar powered satellites, with emphasis on construction and costs is studied. C.F.W.

A79-41220 # Wind energy utilization by means of aerogenerators (Utilizzazione dell'energia eolica mediante aerogeneratori). S. Raccaluto. *Rivista di Meteorologia Aeronautica*, vol. 39, Jan.-Mar. 1979, p. 47-56. 8 refs. In Italian.

Meteorological factors associated with choosing the proper site for wind energy conversion systems are examined with emphasis on wind velocity considerations. This choice is shown to depend on the meteorological and morphological characteristics of a given site and on the manner of utilization of the electrical energy produced. These various factors are considered in planning the wind energy system on the Ustica Island. B.J.

A79-41235 Composite rotor blades for large wind energy installations (Composite-Rotorblatt für Grosse Windenergieanlage Growian). A. Kussmann, J.-P. Molly, and D. Muser (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Bauweisen- und Konstruktionsforschung, Stuttgart, West Germany). *DFVLR-Nachrichten*, June 1979, p. 40-44. In German.

The design of large wind power systems in Germany is reviewed with attention given to elaboration of the total wind energy system, aerodynamic design of the rotor blade, and wind loading effects. Particular consideration is given to the development of composite glass fiber/plastic or carbon fiber/plastic rotor blades for such installations. B.J.

A79-41239 Integrated solar energy installations for isolated operation (Integrierte Solarenergieanlagen für den 'Inselbetrieb'). R. Köhne and K. R. Schreitmüller (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für technische Physik, Stuttgart, West Germany). *DFVLR-Nachrichten*, June 1979, p. 56-58. In German.

Field studies and computer simulations have been devoted to the development of solar energy systems for places isolated from power grids or conventional means of energy supply; these autonomous systems are being developed to supply a wide variety of needs, ranging from hot water to electric power, for isolated dwellings. The integrated system would involve combinations of flat-plate collectors, compound parabolic concentrators, cylindrical-parabolic collectors, rotation-parabolic collectors, and photovoltaic cells. Some typical results on efficiencies, temperatures, and costs are presented. B.J.

A79-41241 Energy consumption structures in the year 2000 (Energieverbrauchsstrukturen im Jahr 2000). J. Nitsch and T. Schott (Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt, Institut für Technische Physik, Stuttgart, West Germany). *DFVLR-Nachrichten*, June 1979, p. 66-69. In German.

The present paper deals with the development of secondary power systems within the framework of an applied systems analysis program. Owing to the development of alternative power supply situations by the year 2000, a variety of secondary power systems should become available on the market. It is seen that by the year 2000, the growth in power consumption will be severely limited by saturation of the market, power saving regulations, and last but not least by continuously increasing costs. V.P.

A79-41254 Fixed-focal-axis solar concentrators with a curvature determined by gravity. G. A. Rottigni (Genova, Università, Genoa, Italy). *Nuovo Cimento C, Serie 1*, vol. 2C, Jan.-Feb. 1979, p. 88-100. 6 refs.

Solar concentrators with a curvature determined by the force of gravity and capable of concentrating solar radiation along a fixed focal axis are analyzed. These concentrators have two reflecting-surface units with a catenary profile determined by gravity. Three such concentrators with an inclination of 35 deg over the horizontal plane and a 24.41-m aperture are considered which differ only in the relative position of the fixed collector. The amounts of energy transmitted to the collector by the different concentrators are estimated and compared. F.G.M.

A79-41371 Design criteria and operational guidelines for a pilot-scale anaerobic digester. J. R. Fischer (U.S. Department of Agriculture, Columbia, Mo.), D. M. Sievers, and C. D. Fulhage (Missouri-Columbia, University, Columbia, Mo.). *Resource Recovery and Conservation*, vol. 4, May 1979, p. 1-11. 7 refs.

Design considerations for constructing a pilot anaerobic digester are presented. A 4.34-cu m pilot digester was constructed by using these criteria. Operational guidelines are presented. Also included are an iterative technique for sizing an internal heat exchanger, suggestions for selecting pumps, meters, and other equipment, and an electrical control system that permits automation of the entire system. The pilot digester operated successfully for more than 4 years with swine manure as a feedstock at a loading rate of 4 kg volatile solids per cu m per day with a 15-day detention time at 35 C. Energy balances indicate that the overall energy efficiency of the digester is a function of the ambient temperature surrounding the digester, the amount of agitation, and the amount of insulation. (Author)

A79-41374 30 years of refuse-fired boiler experience. C. O. Velzy (Charles R. Velzy Associates, Inc., Armonk, N.Y.). (*Engineering Foundation, Conference, Franklin Pierce College, Rindge, N.H., July 1978.*) *Resource Recovery and Conservation*, vol. 4, May 1979, p. 83-98. 13 refs.

The Town of Hempstead has been operating energy from refuse plants since 1950. This paper presents the experience gained from the operation of the Town's two heat recovery plants specifically in the areas of boiler tube metal wastage, boiler fouling, particulate emission control, and maintenance and availability experience. Almost 30 years ago the Town of Hempstead began a pioneering experience in waste heat extraction from mass burning of refuse at Merrick, New York. This plant incorporated waste heat boilers and produced power so as to be totally independent of the local power system. In 1962 our firm was authorized to design a second mass burning refuse incinerator with boilers and power generation for the Town of Hempstead at Oceanside, New York. This paper outlines the experience gained at these two installations over the past 30 years. (Author)

A79-41375 An information approach to examining developments in an energy technology - Coal gasification. J. D. Frame, J. J. Baum (Computer Horizons, Inc., Washington, D.C.), and M. Card (U.S. Department of Energy, Office of Policy and Evaluation, Washington, D.C.). *American Society for Information Science, Journal*, vol. 30, July 1979, p. 193-201. Contract No. EX-76-C-10-3863.

Developments in coal gasification research are investigated by examining the coal gasification literature, which is broadly defined to include journal articles, research reports, engineering proceedings, and patents. A substantial number of items were found for 1974, 1975, and the early part of 1976 (N = 1461). The coal gasification literature has experienced explosive growth in recent years, trebling in size between 1972 and 1974. While some of this growth may be associated with the recent 'energy crisis', in large measure it appears to be associated with the establishment of bench-scale and pilot plant coal gasification operations in the late 1960s and early 1970s. Most published coal gasification research is produced by the U.S. private sector (38.7%), followed by the U.S. government (24.0%), foreign researchers (20.5%), universities (8.5%), and 'unknown' (8.5%). This study suggests that technologies which are government supported and reported in the public domain are - like most scientific areas - good candidates for bibliometric inquiries. These inquiries allow for relatively economic, efficient, and reliable examinations of national research activity in given scientific and technological areas. (Author)

A79-41732 # Spectral-selective surfaces for the thermal conversion of solar energy. M. van der Leij. Delft, Technische Hogeschool, Doctor in de technische Wetenschappen Dissertation, 1979. 164 p. 123 refs.

This thesis covers the study of spectral-selective surfaces for flat plate collectors and the measurement of the main radiation quantities in the direct conversion of solar into thermal energy, and it is aimed to develop high radiant efficiency material. Solar energy conversion processes and selective-absorber surfaces, the definitions and calculations of radiation and optical quantities related to the spectral-selective surfaces and radiation measurements, and the influence of the spectral energy distribution of solar radiation at sea level and of a solar simulator on the solar acceptance are discussed. Experimental techniques including the spectral reflectance and the total emittance measurements are described. Preparation and testing of the spectral-selective materials, iron oxide on steel, zinc chromate on zinc, black zinc oxide on zinc, tungsten oxide on nickel and the optimization of cobalt oxide on nickel plated steel and doped tin dioxide on glass and black-enamelled steel are discussed. Finally, selective surfaces were compared with respect to their collector efficiency and cost with a black-painted surface. A.T.

A79-41801 INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2 - New energy (INOVA: Innovation industrielle; Conférence, Paris, France, June 13-17, 1977, Comptes Rendus. Volume 2 - Energies nouvelles). Paris, Ministère de l'Industrie, 1978. 525 p. In French and English.

The volume presents papers in such fields as solar energy, the economic evaluation of recoverable energy (e.g., tar sands, in situ gasification, and waste), and geothermal energy. Nuclear power development and utilization are discussed in some detail with particular attention given to the transition to a nuclear economy and the relationship of nuclear energy to other technologies. B.J.

A79-41802 Production, transport, and storage of hydrogen (Production, transport et stockage de l'hydrogène). J. Pottier (Gaz de France, Paris, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 17-27. 5 refs. In French.

Different hydrogen production methods are briefly reviewed, including partial oxidation of hydrocarbons, electrolysis, the use of nuclear energy for methane processing, thermochemical treatment,

and coal gasification. Consideration is then given to different hydrogen storage procedures, including liquefaction, storage in the form of hydrides, and storage in cavities and in aquifers. Some considerations on the large-volume transport of hydrogen are given and the perspectives on the development of a hydrogen economy are presented. B.J.

A79-41803 **Transport, distribution and storage of heat by water - Status and developments.** P. Margen (AB Atomenergie, Nyköping, Sweden). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 28-44. 8 refs.

The paper discusses district heating systems that use hot water as the transport and distribution medium from points of view of economics, fuel conservation, environmental considerations, and the possibilities provided by the development of new transport and storage techniques. Consideration is given to (1) classical district heating schemes for urban cores, (2) extension to low heat density one family house districts in the outer urban regions, and (3) planned extensions to large regional schemes. The concept of 'mini-heat utilities' for isolated housing areas supplied by central heat pumps or central solar plants with seasonal heat storage is examined. B.J.

A79-41804 **Storage of electricity (Le stockage d'électricité).** M. Jacquier (Société des Accumulateurs Fixes et de Traction, Levallois Perret, Hauts-de-Seine, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 45-53. In French.

The current status of storage battery technology is surveyed. After a brief review of the conventional lead battery, consideration is given to the more advanced types including (1) such low temperature batteries as Redox and Zn/C12 and (2) such high temperature batteries as sodium-sulfur (300-350 C), lithium-sulfur (450-500 C), and sodium-antimony chloride (200-240 C). B.J.

A79-41805 **Solar energy - Principal directions of research (L'énergie solaire - Principales voies de recherche).** M. Rodot (CNRS, Meudon, Bellevue, Hauts-de-Seine, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 60-68. In French.

After some brief considerations on the rationale behind solar energy utilization, the paper discusses such primary processes as bioconversion of solar energy and solar heating. Two principal directions of solar energy conversion are surveyed: (1) production of electrical and mechanical energy without concentration (through solar cells and low-temperature thermodynamic cycles); and (2) production of energy with concentration (through concentrating arrays, thermal systems with distributed receivers, and solar thermal plants). The French National solar energy program is briefly discussed. B.J.

A79-41807 **The Odeillo solar electric power plant (Centrale électrosolaire d'Odeillo).** J.-L. Peube and B. D'Utruy (CNRS, Laboratoire d'Energétique Solaire, Font-Romeu, Pyrénées-Orientales, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 77-81. In French.

The principles of thermodynamic conversion of solar energy into electricity are reviewed. A solar power plant has been constructed at Odeillo (on the basis of the solar furnace already existing there) using these thermodynamic principles. The design and operation of the plant are described and consideration is given to several other solar projects including INTI 800, THEK, and PERICLES. B.J.

A79-41808 **Bioconversion of solar energy (Bioconversion de l'énergie solaire).** P. Chartier (Institut National de la Recherche Agronomique, Versailles, France). In: INOVA: Industrial innovation;

Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 84-97. 20 refs. In French.

The paper describes biomass production through photosynthesis and compares biomass energy yield with yields from incident solar radiation and from conventional fossil fuel sources. The areas of land that will have to be devoted to biomass production in order to make this energy source worthwhile are examined and consideration is given to the modes of biomass utilization as an energy source, including the meeting of decentralized energy requirements and the distribution on a massive scale of solid, liquid or gaseous combustibles. The perspectives of biological solar energy conversion systems are considered. B.J.

A79-41809 **Solar photovoltaic energy (L'énergie solaire photovoltaïque).** J. Caheux and P. Fayet (Centre National d'Etudes Spatiales, Toulouse, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 98-113.

In French.

After a brief review of some problems associated with solar energy, the paper discusses the principles behind solar cell operation. Various cell structures (homojunction, heterojunction, Schottky junction, and variable forbidden band) are considered along with cell materials (silicon, Group III-V compounds, and Group I-II-VI compounds). Several large scale applications without storage are examined. B.J.

A79-41810 **Ocean thermal energy (L'énergie thermique des mers).** A. Brin (Ministère de l'Industrie, Direction des Mines, Paris, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 114-122. In French.

Among the means of solar energy utilization, the OTEC concept presents a number of advantages. These include the vast quantity of the basic resource, the large regional distribution, weak seasonal variation (making storage unnecessary), and the capability of using already developed technology. The prime disadvantage is that the low efficiency of the process will require the construction of plants on a vast scale. This paper briefly reviews open-cycle and closed-cycle OTEC operation and presents some technical data on OTEC plants. B.J.

A79-41811 **Constraints on a policy of evaluating recoverable energy (Les conditions d'une politique de valorisation d'énergies récupérables).** M. Berard (Agence Nationale pour la Valorisation de la Recherche, Neuilly-sur-Seine, Hauts-de-Seine, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 125-130. In French.

The paper considers ways to economically evaluate sources of recoverable energy, i.e., those sources (tar sands, in situ coal gasification, refuse utilization, etc.) that become feasible when conventional fossil fuel sources become more expensive. Three elements that condition a policy on recoverable energy are discussed, including (1) economic criteria, (2) interaction between energies, management of natural resources, and protection of the environment, and (3) political imperatives involving reduction of energy imports. B.J.

A79-41812 **Development of the oil sands of Canada.** J. M. Denis, B. B. Pruden, and C. Lafkas (Department of Energy, Mines and Resources, Canada Centre for Mineral and Energy Technology, Ottawa, Canada). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 131-136. 7 refs.

The estimated amount of bitumen in the Alberta oil sands is of the order of 1000 billion barrels; this quantity exceeds the known

world reserves of oil by 50 percent. However, a large part of this bitumen is either too deeply buried or too thinly concentrated for possible economic recovery. A thermal hydrocracking process has been developed for application to the Alberta oil sands. Hydrogen-rich gas and bitumen are preheated and passed through a high pressure reactor where the feed is cracked and hydrogen is added. It is hoped that the choice of the upgrading of Canadian bitumen to demonstrate thermal hydrocracking will serve to emphasize that possibilities for this process are worldwide and not confined to any specific feedstock. B.J.

A79-41813 Oil shale technologies and the potential for oil shale development. A. W. Decora, H. C. Carpentier, and H. B. Jensen (U.S. Department of Energy, Laramie Energy Research Center, Laramie, Wyo.). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie, 1978, p. 137-146. 14

refs.

The technical feasibility of producing liquid hydrocarbon products from aboveground retorts has been established on a pilot plant scale. Many of these processes - the gas-combustion process, the Paraho process, the Union Oil process, and the TOSCO II process - have operated successfully at rates as high as 1000 tons per day. However, these processes must be scaled up by 10 to 20 times to contribute significantly to future energy supplies. Successful operation of commercial-sized modules is needed to provide realistic data for an economic analysis of an oil shale retorting process. This development will require several years if oil shale is to contribute significantly to near-term energy supply in the U.S. B.J.

A79-41814 Assisted recovery of new oil reserves (La récupération assistée - De nouvelles réserves de pétrole). P. Simandoux (Institut Français du Pétrole, Division Gisements, Rueil-Malmaison, Hauts-de-Seine, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie, 1978,

p. 147-158. In French.

The paper reviews three types of methods for the assisted recovery of crude oil from mineral deposits: (1) injection of miscible gas, (2) injection of water with chemical additives, and (3) thermal methods (i.e., steam injection and in situ combustion) for heavy crudes. Some essential characteristics of the application of these methods are discussed, including diversity, technical risk, and costs. B.J.

A79-41815 In situ coal gasification - New energy source for Europe (La gazéification souterraine du charbon - Nouvelle source d'énergie pour l'Europe). P. Ledent (Institut National des Industries Extractives, Liège, Belgium). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie,

1978, p. 159-173. In French.

The paper briefly describes the current status of the in situ coal gasification technique and attempts to demonstrate how this process can become one of the principal energy sources for Europe by the year 2000. Consideration is given to in situ gasification at shallow depths and at great depths, and a three-stage development process for high-pressure gasification is proposed. Energy yields and costs are discussed in some detail. B.J.

A79-41817 Classification and energy evaluation of urban wastes (Tri et valorisation énergétique des ordures ménagères). J.-N. Gony (Bureau de Recherches Géologiques et Minières, Orléans, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie, 1978, p. 181-192. 5 refs. In

French.

Several processes developed in the United States for the conversion and recovery of urban refuse are described. These include (1) utilization of crude solid waste (the Union Electric process); (2) preparation of a refined solid waste fuel (the Ecofuel and Combor

process); (3) recovery of liquid hydrocarbons (the Garret process); and (4) methane production (the Biogas process). Technical data on the various processes are presented. B.J.

A79-41818 Substitute fuels and development of recovery methods (Combustibles de substitution et synthèse des méthodes de récupération). H. Brusset (Paris VI, Université; Ecole Centrale des Arts et Manufactures, Paris, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie, 1978,

p. 193-200. In French.

After a brief discussion of the general energy problem (i.e., the depletion of conventional fossil fuels), the paper examines the development of substitute energy sources, including oil shale, bituminous sands, bituminous schists, coal, biomass, and urban waste. Techniques for the economic evaluation of such substitute fuels are briefly discussed and carbon is examined as the principal 'energy vector'. B.J.

A79-41819 Exploration and exploitation techniques for geothermal resources (Les techniques de recherche et d'exploitation de la ressource géothermique). J. Lavigne (Bureau de Recherches Géologiques et Minières, Orléans, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie,

1978, p. 209-218. In French.

Methods used in detecting and developing geothermal resources are reviewed. Special attention is given to low energy resources, aquifers where heat transfer is primarily by conduction and water occurs in liquid form. Geothermal installations operating in France are described briefly, and the technological characteristics of different types of deep wells are outlined. The problem of cold water reinjection is examined. C.K.D.

A79-41820 Long term perspectives in energy resources (Perspectives à long terme en matière de ressources d'énergie). C. Destival (Commissariat Général au Plan, Paris, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de

l'Industrie, 1978, p. 297-302. In French.

Long term perspectives in global energy use patterns and energy resources are considered. The potential contributions of natural gas and coal, oil, nuclear energy, hydroelectric energy, and alternative energy resources (geothermal, wind, biomass, solar) are evaluated. It is concluded that fossil fuels will continue to provide the bulk of the world's energy through the upcoming decades. The political uncertainty of the supply of these fuels will force nations to develop costlier energy technologies. The medium term energy requirements will best be met by intensive development of nuclear energy. C.K.D.

A79-41821 Rational utilization of electricity in order to satisfy the general objectives of the national energy policy (L'utilisation rationnelle de l'électricité pour satisfaire les objectifs généraux de la politique énergétique nationale). J. Bouchet (Electricité de France, Service d'Etude et de Promotion de l'Action Commerciale, Paris, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2.

Paris, Ministère de l'Industrie, 1978, p. 317-323. In French.

French energy policy focuses on energy conservation and large-scale nuclear-power development. This paper discusses French energy needs in the context of the benefits of nuclear power. Consideration is given to the time scale for nuclear power development, practical motivations for transition to a nuclear economy, the need for innovations and rational utilization of electricity, the evolution of electricity costs, and perspectives for future investments. B.J.

A79-41822 Some advantages to be expected from the optimization and automation of industrial processes - Conservations of primary energy and raw materials and better use of electricity

(Quelques avantages escomptables de l'optimisation et de l'automatisation des processus industriels - Economies d'énergie primaire, économies de matières premières et meilleure pénétration de l'électricité). R. Chaussard (Electricité de France, Direction des Etudes et Recherches, Chaton, Yvelines, France). In: INOVA: Industrial innovation; Conference, Paris, France, June 13-17, 1977, Proceedings. Volume 2. Paris, Ministère de l'Industrie, 1978, p. 398-413. In French.

The evolution of energy demand and resources in France from 1973 to the present is discussed, and future trends are considered. An increased dependence on electricity as the major form of energy in industry is predicted. The importance of conserving petroleum as an essential resource for the chemical industry is emphasized. A methodology for determining the energy needs of industries on the scale of the individual plant or workshop and for identifying cost-effective means of reducing the amount of fossil fuel consumed in a given process in favor of electricity is discussed. The general approach consists of preliminary technico-economic studies followed by simulation procedures. Specific examples of the application of this method to a foundry, distillation processes, and a zinc plant are presented.

C.K.D.

A79-41831 * # Optimal control of sun tracking solar concentrators. R. O. Hughes (California Institute of Technology, Jet Propulsion Laboratory, Control and Energy Conversion Div., Pasadena, Calif.). (International Solar Energy Society, Annual Meeting, Denver, Colo., Aug. 28-31, 1978.) ASME, Transactions, Journal of Dynamic Systems, Measurement, and Control, vol. 101, June 1979, p. 157-161. 9 refs. Research sponsored by the U.S. Department of Energy; Contract No. NAS7-100.

Application of the modern control theory to derive an optimal sun tracking control for a point focusing solar concentrator is presented. A standard tracking problem converted to regulator problem using a sun rate input achieves an almost zero steady state tracking error with the optimal control formulation. However, these control techniques are costly because optimal type algorithms require large computing systems, thus they will be used mainly as comparison standards for other types of control algorithms and help in their development.

A.T.

A79-41842 A study of waveguides for far infrared interferometers measuring electron density of tokamak plasmas. J. P. Crenn (EURATOM and Commissariat à l'Energie Atomique sur la Fusion, Département de Physique du Plasma et de la Fusion Contrôlée, Fontenay-aux-Roses, Hauts-de-Seine, France). IEEE Transactions on Microwave Theory and Techniques, vol. MTT-27, June 1979, p. 573-577. 21 refs.

In the 0.1-1-mm wavelength range, waveguide propagation offers some advantages over optical propagation in multichannel infrared interferometers measuring electron density of tokamak plasmas. In this paper, the necessary conditions for use of waveguides for this purpose are defined. Possible waveguides are theoretically and experimentally studied, taking into account their shape, size, material, and length. It is shown that it is possible to find waveguides well suited for these interferometers. These results can also be applied to other far infrared interferometers and devices. (Author)

A79-41913 # Nuclear aircraft innovations and applications. J. C. Muehlbauer (Lockheed-Georgia Co., Marietta, Ga.) and R. E. Thompson (Westinghouse Electric Corp., Advanced Energy Systems Div., Pittsburgh, Pa.). American Institute of Aeronautics and Astronautics, Very Large Vehicle Conference, Arlington, Va., Apr. 26, 27, 1979, Paper 79-0846. 15 p. 18 refs.

Determination of the minimum weight nuclear propulsion cycle and aircraft configuration, identification of technologies and innovations for enhancing mission accomplishment, and evaluation of alternate mission applications in the framework of the Innovative Aircraft Design Study (IADS) program are discussed. Parametric studies of four aircraft configurations showed the minimum weight configuration to be one which carries the payload and reactor in the

fuselage and uses a canard surface for horizontal control. A Bi-Brayton propulsion cycle with a gas cooled reactor and dual mode engines offers the potential for the lightest weight nuclear aircraft. While sea control, cruise missile carrier, tanker, and airborne command post are prospective alternate mission applications, the nuclear powered cruise missile carrier aircraft (NuCMCA) concept provides unique strategic capabilities.

V.T.

A79-41931 # Engineering of microwave relays (Ingénierie des faisceaux hertziens). S. Bonhoff (Thomson-CSF, Division Faisceaux Hertiens et Liaisons Spatiales, Levallois-Perret, Hauts-de-Seine, France). Revue Technique Thomson - CSF, vol. 11, June 1979, p. 417-484. 7 refs. In French.

The paper examines the constraints upon microwave relay systems and shows how these constraints affect the choice of solutions for implementing radio equipment. Consideration is given to the role of signal fading in the optimization and utilization of RF power. Social factors and the impact of technological progress on the implementation of microwave relays are discussed. Energy supplies (i.e., storage batteries, solar cells, wind systems, thermoelectric generators, Rankine turboalternators, and motor-generator systems), are discussed along with siting considerations for microwave relays.

B.J.

A79-41935 Transient response of a solar regenerator. P. Gandhidasan, V. Sriramulu, and M. C. Gupta (Indian Institute of Technology, Madras, India). Applied Scientific Research, vol. 34, Summer-Fall 1978, p. 259-271. 7 refs.

Since a solution-air solar regenerator is exposed continuously to varying insolation, the instantaneous transfer process can be significantly different from quasisteady conditions. In the present analysis the first order deviations of the instantaneous conditions from the quasisteady conditions have been considered by solving the governing unsteady laminar boundary layer equations. The results show that early in the morning and late in the evening the instantaneous values are different from quasisteady values, but the deviation is insignificant for the two hours preceding and following noon, particularly for mass transfer coefficients, which determine the performance of the regenerator. The study further reveals that the ratio of solution velocity to air velocity also influences the performance of the regenerator. (Author)

A79-41939 Dynamics of high-beta tokamaks with anisotropic pressure. P. J. Fielding and F. A. Haas (EURATOM and U.K. Atomic Energy Authority Fusion Association, Culham Laboratory, Abingdon, Oxon, England). Nuclear Fusion, vol. 19, July 1979, p. 855-867. 20 refs.

On the basis of a high-beta long-wavelength ordering, the Chew-Goldberger-Low (CGL) equations are used to discuss the dynamics and linear stability of a general anisotropic plasma-vacuum tokamak. The multiple time-scale method is used to derive a reduced set of nonlinear MHD equations. To lowest order, the perpendicular component of pressure is not necessarily constant on the flux surfaces. A simple example of such an equilibrium is given; a heuristic treatment of the Fokker-Planck equation shows that equilibria of this type can only be established by near-perpendicular injection. For practical distribution functions representative of a beam-injected plasma, comparison with the Andreoletti (1963) energy principle shows that the CGL principle never overestimates stability. For an effective pressure (equal to half the sum of the parallel and perpendicular pressure components) that is constant on flux surfaces, the MHD linear stability of an anisotropic tokamak to long-wavelength modes is identical (within the ordering) to that for the equivalent scalar-pressure tokamak. A similar result has recently been obtained in the limit of short-wavelengths for fixed-boundary modes (ballooning). (Author)

A79-41940 Analytic computation of minimum beta at ignition for various transport scaling laws. R. W. Harvey and J. M.

Rawls (General Atomic Co., San Diego, Calif.). *Nuclear Fusion*, vol. 19, July 1979, p. 869-875. 23 refs. Contract No. EY-76-C-03-0167.

Tokamak ignition conditions are analyzed by using a general scaling law where energy confinement time is proportional to electron plasma density times plasma temperature to the j -th power. The resulting expressions are evaluated parametrically in terms of the constant of proportionality and the exponent, j . Simplifying assumptions are made to permit an analytical treatment of the problem, and a simple algebraic relationship for the minimum beta is obtained along with expressions for the associated density and temperature at the minimum-beta ignition point. It is found that the temperature corresponding to the minimum-beta ignition point depends on the scaling law only through the exponent, j , and that this temperature is independent of plasma size, plasma shape, and toroidal magnetic field. The results are applied to a representative ignition-grade plasma. F.G.M.

A79-41941 Non-linear saturation of the tearing mode in a reversed field pinch. D. Schnack and J. Killeen (California, University, Livermore, Calif.). *Nuclear Fusion*, vol. 19, July 1979, p. 877-887. 12 refs. Contract No. W-7405-eng-48.

A nonlinear two-dimensional resistive MHD computer code is used to study the nonlinear behavior of the $m = 0, 1$, and 2 tearing modes in a reversed-field pinch. For the cases where m is not equal to zero, a coordinate transformation which assumes helical symmetry is employed to reduce the dimensionality of the problem from three to two. The force-free Bessel-function model equilibrium is used. It is found that the most dangerous resistive instability in this case is the $m = 1$ tearing mode, because of its larger growth rate and extended period of exponential growth. (Author)

A79-41942 Plasma-surface interactions in tokamaks. G. M. McCracken and P. E. Stott (EURATOM and U.K. Atomic Energy Authority, Fusion Association, Culham Laboratory, Abingdon, Oxon, England). *Nuclear Fusion*, vol. 19, July 1979, p. 889-981. 351 refs.

A summary is given of the present status of research on plasma-surface interactions in tokamaks. Three groups of important interactions are considered: recycling of the principal ion species, usually hydrogen or deuterium; the release and effect of low-Z contaminants; and the release and effect of high-Z contaminants. In each case the basic physical processes are reviewed and the relevant data from particle-beam measurements are summarized. Emphasis is given to discussing the effect of the various surface interactions in present-day tokamak discharges and in future fusion reactors. Surface studies in tokamaks are reviewed and methods of controlling the surface interactions and their effects are considered. (Author)

A79-41943 Anomalous diffusion and transport beta limits in dense tokamak plasmas. R. D. Stambaugh and J. M. Rawls (General Atomic Co., San Diego, Calif.). *Nuclear Fusion*, vol. 19, July 1979, p. 983-987. 16 refs. Contract No. EY-76-C-03-0167.

The maximum operating density in several high-density tokamak discharges is investigated for the case where the simple technique of gas puffing at the plasma boundary is applied to raise the plasma density. The flux-balance relation is treated analytically, and an upper limit on the central electron beta is obtained. The anomalous particle diffusion coefficient is computed by comparing the flux-balance relation with experimental data, the dependence of anomalous transport on plasma and machine parameters is deduced, and neoclassical fluxes are evaluated by using exact expressions. It is found that the anomalous particle diffusion coefficient is inversely proportional to electron plasma density. A similar analysis reveals that the thermal diffusion coefficient also scales as the inverse of electron plasma density. F.G.M.

A79-41944 Measurements of plasma shape in a tokamak. A. J. Wootton (EURATOM and U.K. Atomic Energy Authority Fusion Association, Culham Laboratory, Abingdon, Oxon, England). *Nuclear Fusion*, vol. 19, July 1979, p. 987-990. 9 refs.

Magnetic-field measurements on a small tokamak, TOSCA, are described. Modified Rogowski and saddle coils are used to determine

toroidal multipole moments of the plasma current density, from which the plasma position and shape are derived. Results are presented for a plasma distorted by a hexapole magnetic field.

(Author)

A79-41946 Off-shore based wind turbine systems /OS-WTS/ for Sweden - A systems concept study. R. Hardell (SIKOB AB, Sweden) and O. Ljungstrom (Flygtekniska Forsoksanstalten, Bromma, Sweden). (British Hydromechanics Research Association, International Symposium on Wind Energy Systems, 2nd, Amsterdam, Netherlands, Oct. 3-5, 1978.) *Wind Engineering*, vol. 3, no. 1, 1979, p. 22-51. 12 refs.

Off-shore (OS) sites may prove to be more cost-effective and will reduce the land requirements for wind turbine systems (WTS) in Sweden. For sites located 10-20 km off shore, the median wind increases to 8.5 - 9.5 m/s ($H=100$ m) and the specific energy output (per turbine disc area) increases by 40%. Examples of design concepts of 7-14 MW unit capacity are given with associated cost estimates and with outlooks for the bigger second generation designs of 20-30 MW units. Environmental, social, and industrial aspects and impact of OS-WTS are discussed in comparison with land based systems. The OS-WTS advantages are: flexibility of site selection, good serviceability, and possibility to export to other countries by sea transport. Some disadvantages are: more severe environment at sea, higher costs for network attachment, and inspection difficulties in bad weather conditions. V.T.

A79-41947 Concentration augmentation of power in a Savonius-type wind rotor. S. Sivasegaram (University of Sri Lanka, Peradeniya, Sri Lanka). *Wind Engineering*, vol. 3, no. 1, 1979, p. 52-61. 6 refs.

The power output of wind turbines is restricted by the diffuse nature of wind energy. Several methods are available for augmenting the power output of horizontal-axis wind turbines, but these methods are not suitable for use with vertical axis wind turbines. The possibility of using concentrators to augment the power output of a Savonius rotor has already been demonstrated. This paper reports a detailed experimental investigation, based on model tests, for determining the optimum design parameters of a concentrator augmentation system and discusses the influence of the geometric parameters of a symmetrical, straight-walled concentrator on the performance of a Savonius-type wind rotor. (Author)

A79-41948 Optimal value of the rated speed of a wind generator. M. Diesendorf (Commonwealth Scientific and Industrial Research Organization, Div. of Mathematics and Statistics, Canberra, Australia) and G. Fulford. *Wind Engineering*, vol. 3, no. 1, 1979, p. 62-68. 10 refs.

In this paper, South Australian windspeed data are modelled with the Weibull distribution, while the response (i.e. power density output) of a wind generator, between its starting speed and rated speed, is chosen to be the sum of a cubic function of windspeed and a constant term. An expression is derived for the value of the parameter which yields the maximum of the annual energy production. In the particular case when the two-parameter Weibull distribution reduces to the one-parameter Rayleigh distribution, which is a fairly good fit to the data studied, the values of the parameters of interest are (rated speed/mean windspeed) $\max = 2.04$ and (mean of the cubed windspeed/cube of the mean windspeed) $= 1.9$. Attention is drawn to the important role of the starting speed of the wind generator, which determines, together with the rated speed, whether there is a maximum annual energy production and, if so, where in parameter space the maximum is to be found. V.T.

A79-42030 Studies on two-phase flow mixing pertaining to liquid-metal magnetohydrodynamic power generation. G. Fabris, P. F. Dunn (Argonne National Laboratory, Argonne, Ill.), J. C. F. Chow, and R. Kolp. In: Biennial Symposium on Turbulence, 5th, Rolla, Mo., October 3-5, 1977. Proceedings. Princeton, N.J., Science Press, 1979, p. 41-50; Discussion, p. 50. 11 refs. Research sponsored by the U.S. Department of Energy and U.S. Navy.

The experimental work described was conducted to evaluate the fluid mechanical performance of various two-phase liquid-metal MHD mixer designs. The results indicate that two-phase flow turbulence is not helpful in generating a homogeneous two-phase flow at high void fractions, even in strongly surface-active systems. This is somewhat contrary to the behavior at low void fractions, where turbulence breaks up large bubbles into smaller ones. It appears that in some mixers, churn turbulent slug flow is established and is maintained further downstream, regardless of the surface-activity level. The use of contraction geometries as a means of obtaining a favorable pressure gradient is examined. V.P.

A79-42170 Analysis of AlGaAs-GaInAs cascade solar cell under AM 0-AM 5 spectra. M. F. Lamorte and D. Abbott (Research Triangle Institute, Research Triangle Park, N.C.). *Solid-State Electronics*, vol. 22, May 1979, p.467-473. 7 refs.

It has been shown from first principles, by using the integral form of the transport equations, that the efficiency of a two-junction AlGaAs-GaInAs cascade solar cell optimized at 290 K and under AM0 spectral conditions may exceed 30%. Further studies of this cascade structure have been carried out to determine performance under AM0-AM5 spectral conditions and at a concentration ratio of 1000 over the temperature range 290-600 K. In addition, the two-junction AlGaAs-GaInAs cascade cell has been optimized at 290 K and under AM1.5 spectral conditions. The performance characteristics of the designs optimized under AM0 and AM1.5 conditions are compared over the temperature range 290-600 K. The AM0 optimized structure was used as the initial structure to determine the optimized structure under AM1.5 spectral conditions. The results of the computer modeling show that the optimized wide-bandgap cell parameters under AM0 and AM1.5 are somewhat different. However, the optimized narrow-bandgap cell parameters are identical for AM0 and AM1.5. The theoretical efficiency increases with increasing concentration ratio, approaching 40% at a concentration ratio of 1000. (Author)

A79-42171 Zn/x/Cd/1-x/S/Cu2S heterojunction solar cells. I - Fabrication and performance. A. Banerjee, S. R. Das, A. P. Thakoor, H. S. Randhawa, and K. L. Chopra (Indian Institute of Technology, Delhi, India). *Solid-State Electronics*, vol. 22, May 1979, p. 495-499. 13 refs. Research supported by the Department of Science and Technology of India.

Alloy films of Zn(x)Cd(1-x)S have been prepared by both vacuum evaporation and spray pyrolysis. Junctions of these films with Cu2S have been formed by the solid-state reaction for the evaporated alloy films and by the conventional chemiplating technique for the spray-deposited alloy films. The current-voltage characteristics, diffusion length of minority carriers, and spectral response of the cells have been determined. Highest conversion efficiency for the evaporated cells is 6.5%, corresponding to $x = 0$, and for the sprayed cells is 5.6%, corresponding to $x = 0.1$. The cell performance has been analyzed and further scope of improvement indicated. (Author)

A79-42220 NOx formation with various combustion processes of premixed gas. S. Miura, T. Tsukamoto, M. Kawagoe, S. Nakaoji, and Y. Kaneko (Mitsubishi Motors Corp., Tokyo, Japan). *Mitsubishi Heavy Industries Technical Review*, vol. 16, Feb. 1979, p. 44-55. 8 refs.

Studies have been carried out to reduce the exhaust emissions of the spark-ignition engines, however, it is fairly difficult to reduce NOx emissions by an after-treatment device, therefore, efforts have been conducted to reduce NOx emissions by improving the combustion process. The paper shows the results of studies on the NOx emission with combustion of methane-air premixed gas for various types of combustion processes using experimental combustion vessels. It was confirmed that NOx concentrations of most types of combustion processes were relative to their maximum pressures of pressure-time traces. However, low NOx concentrations with high maximum pressure were obtained when unburnt gas was disturbed by turbulent jet flame. (Author)

A79-42226 Peak period of household load in the different stages of electrical power supply (Der Spitzenanteil der Haushaltbelastung in den einzelnen Stufen der Elektrizitätsversorgung). P. Grünberg (Kreiswerke Heinsberg GmbH, Geilenkirchen, West Germany). *Brennstoff-Wärme-Kraft*, vol. 31, June 1979, p. 239-244. 5 refs. In German.

The results of an extensive and long term investigation into household power consumption are examined using two different methods which determined that households represent up to 70% of the peak load for a city utility. The first method involves analysis of seven years of data from eight power plants, while the second is based on the premise that daily peak loads follow a typical pattern. Topics discussed include standardized peak load curves for household customers and the frequency of high load period at West German utilities. A formula for determining the mean peak period factor is presented. It is concluded that the effect of households on the peak load can no longer be regarded as minimal. M.E.P.

A79-42227 Development and thermodynamic layout of a fuel cell component (Zur Entwicklung und thermodynamischen Auslegung eines Brennstoffzellen-Aggregats). S. Reul and U. Wieland (Telefunken AG, Hamburg, West Germany). *Brennstoff-Wärme-Kraft*, vol. 31, June 1979, p. 244-250. In German.

The current development status and thermodynamic layout of fuel cells and gas supply for a 1 kW fuel cell component are described. Attention is given to the AEG-Telefunken developed fuel cell with an acid electrolyte and noble metal anode. Discussion covers the measurements made with blocks of 40 cells. Voltage curves with different fuels such as oxygen/hydrogen, oxygen/air, and product gas/air, are presented. Since the use of conventional liquid or gaseous fuels is a condition for commercial use, three fuel supplies are proposed based on methanol and methane which are then also compared in respect to oxygen production. In addition, a methanol cracking reactor is studied. M.E.P.

A79-42228 A method of iteration for calculating the gasification gas composition of hydrocarbons and coal dust at low temperatures and high pressure (Ein Iterationsverfahren zur Berechnung der Vergasungsgas-Zusammensetzung von Kohlenwasserstoffen und Kohlenstäuben bei niedrigen Temperaturen und hohen Drücken). W. Samsel (Niederrhein, Fachhochschule, Krefeld, West Germany). *Brennstoff-Wärme-Kraft*, vol. 31, June 1979, p. 251-255. 7 refs. In German.

A gas composition formula incorporating the three conditions possible during coal gasification is presented. An equation is given representing each of these conditions which are: (1) low concentration of hydrocarbons resulting in soot-free gasification, (2) excess concentration of hydrocarbons resulting in soot formation, and (3) hydrocarbon saturation resulting in gasification at the soot limit. It is noted that the calculations can be performed on a programmable hand calculator. M.E.P.

A79-42248 Determination of the minority carrier diffusion length in silicon solar cells. A. K. Vaseashta, J. D. Arora, and P. C. Mathur (Delhi, University, Delhi, India). *International Journal of Electronics*, vol. 46, May 1979, p. 529-533. 16 refs. Research supported by the University Grants Commission.

Minority carrier diffusion length in the base region of silicon solar cells, fabricated by a diffused junction technique and having a resistivity in the range 0.1-10 ohm cm, has been measured by studying the spectral dependence of the short-circuit current density. The trend of the observed variation of minority carrier diffusion length and lifetime with the doping level of base region is discussed. (Author)

A79-42250 Application of fluidization techniques to the combustion of coal - The state of the art (Application des techniques de fluidisation à la combustion du charbon - Situation de la recherche et du développement). J.-F. Large (Compiègne, Université de Technologie, Compiègne, France). *Revue de l'Energie*, vol. 30, May 1979, p. 412-421. 30 refs. In French.

The state of the art of fluidization processes for coal combustion is discussed. After a review of the advantages offered by fluidization techniques, the different fluidization processes currently in use or under development for burning coal in a fluidized bed are described, including fluidized combustion under pressure and combustion under atmospheric pressure. The principal pilot projects using fluidization techniques are discussed, and factors influencing the choice of a fluidization technology are considered. Theoretical studies involving heat exchange in fluidized beds, air pollution retention and combustion models are surveyed. C.K.D.

A79-42275 # The chemical stability of kerosene fractions (Khimicheskaya stabil'nost' kerosinovykh fraktsii). A. Ivanov, K. Kovacheva, Z. Kutsarova, and S. Vylkova. *Khimiia i Tekhnologiya Topliv i Masel*, no. 6, 1979, p. 6-9. In Russian.

The compositions of the adsorbed resin components of the kerosene fractions of jet fuels which are desorbed by methanol or acetic acid are investigated and the effects of the resins on fuel stability are assessed. Infrared spectroscopy in the region 650 to 4000 kaysers indicates that the major components of the methanol fraction are alcohols, while predominantly organic acids and other carbonyl compounds are observed in the acetic acid fraction. Resins desorbed by methanol are found to inhibit fuel oxidation to a greater degree than resins desorbed by acetic acid, when added in various concentrations to kerosene from which resins and sulfur have been removed. A.L.W.

A79-42350 Ocean and energy (Océan et énergie). A. Brin. Paris, Editions Technip, 1979. 122 p. 12 refs. In French.

The present and possible future role of the world's oceans in energy production and exploitation is examined. The impact of sea-based oil production on the marine environment is discussed, and methods used in developing undersea oil beds are described. Attention is given to the use of nuclear energy in boats, radioactive pollution of the oceans, the effects of large-scale use of seawater to cool reactors, and the possible exploitation of uranium in seawater. A second section discusses the present status of research concerning the use of sea-based alternative energy sources, including tides, waves and currents, temperature differences between surface and underlying water layers, and osmotic pressure. Applications of wind and solar energy in maritime activities are considered. C.K.D.

A79-42424 Recent ooids from different environments - Relationship between petrophysical properties and microstructure. M. Oti and G. Müller (Heidelberg, Universität, Heidelberg, West Germany). *Erdöl und Kohle Erdgas Petrochemie vereinigt mit Brennstoff-Chemie*, vol. 32, Mar. 1979, p. 107-115. 18 refs.

The results of scanning electron microscope studies on recent ooids from different environments are examined, and it is revealed that their microstructures are closely related to petrophysical parameters. Crystal size is the main factor that influences specific surface area and the pore size of intercrystalline pores, whereas crystal orientation primarily determines the porosity. In relatively densely packed parallel structures, the porosity is much lower than in a more open tangential or even randomly packed framework structure. Additional clay content of the ooids results in an enlargement of the specific surface area, but also in a decrease in the size of the intercrystalline pores. There is evidence that cerebroid ooid structures which until now were believed to be exclusively diagenetic features, can also be of primary origin. M.E.P.

A79-42425 Materials, problems and research in German coal conversion projects. K. H. van Heek and W. Wanzl (Berghau Forschung GmbH, Essen, West Germany). (*International Meeting on Materials for the Conversion and Utilization of Coal, Washington, D.C., Oct. 11-13, 1977*). *Erdöl und Kohle Erdgas Petrochemie vereinigt mit Brennstoff-Chemie*, vol. 32, Mar. 1979, p. 116-120. 8 refs.

The present status of R&D of West German coal conversion projects in the areas of gasification, liquefaction, coking and

electricity generation is surveyed. Gasifier projects discussed include the Lurgi, Texaco, Saarberg/Otto process, and the Shell-Koppers gasifiers. Material problem areas include abrasion on heat exchangers and the reactor lining. Liquefaction and coking are covered, with reference to the Lurgi-Ruhrgas and the German Kohleöl processes, noting problems including erosion, corrosion, and hydrogen embrittlement. Consideration is given to the BF-VFW fluidized bed combustion process operating in combination with a gas turbine for the generation of electricity and supply of steam for district heating. Special attention is given to the material program for nuclear coal gasification, noting the higher safety requirements due to the combination of the coal conversion plant with a nuclear reactor. M.E.P.

A79-42458 Energy on the horizon. M. Wayne. *EPRI Journal*, vol. 4, May 1979, p. 6-12.

The energy outlook for the remainder of the 20th century and into the 21st century, is surveyed, noting that conservation has affected domestic energy sources (coal) more than foreign sources (oil). Reasons for conservation, such as higher prices and government policy are cited together with reduced energy demand in home and industrial uses and also reduced auto use and electric cars. With an energy growth rate of less than 3.3% but over 2%, it is predicted that coal use will triple over its 1976 level by 2000, oil use will double and natural gas consumption will also expand. Attention is given to such factors as oil production, the coal outlook, nuclear power, hydroelectric and new energy sources such as wind and solar power. It is concluded that while energy needs can be met for 2000, it will not be possible to meet them only with domestic sources. M.E.P.

A79-42545 * Photon-degradation effects in terrestrial silicon solar cells. V. G. Weizer, H. W. Brandhorst, J. D. Broder, R. E. Hart, and J. H. Lamneck (NASA, Lewis Research Center, Cleveland, Ohio). *Journal of Applied Physics*, vol. 50, June 1979, p. 4443-4449. 10 refs. Contract No. EX-76-A-29-1002.

The effect of instability in terrestrial solar cells and identification of mechanisms involved are presented. The effect is similar to photon-induced degradation in radiation-damaged space solar cells, with reduction in cell output in n(+)/p cells upon exposure to illumination or upon the application of a sufficiently high forward bias. It was found that the photon-degradation effect is caused by a recombination center identified as a complex of a lattice defect and a silver atom or cluster of atoms. The center is electrically inactive in its ground state but can be activated by raising the minority-carrier quasi-Fermi level to coincide with the position of the latent-center level in the band gap, or by direct excitation of electrons from the valence band to the latent-center level. Photon degradation can be prevented by avoiding the introduction of silver through the use of a clean diffusion system and clean initial material, or by eliminating lattice damage by sufficient surface material removal prior to diffusion and restricting diffusion temperatures to 875 C or below. A.T.

A79-42552 # Choice of optimal parameters for a heat exchanger with heat pipes for a gas turbine engine (Vybor optimal'nykh parametrov teploobmennika s teplovymi trubami, prednaznachennogo dlia GTD). N. V. Lokai and I. I. Mosin. *Aviatsionnaia Tekhnika*, vol. 22, no. 1, 1979, p. 41-46. 5 refs. In Russian.

Some means of achieving maximum degree of regeneration in a heat exchanger with heat pipes are investigated by extending some previous analysis methods for heat exchangers with intermediate heat carrier. Two conditions are found which must be satisfied in order to achieve maximum degree of regeneration: (1) the heat transmitting power of the heat pipes must exceed the heat release intensity from both the gas and air directions; and (2) two dimensionless parameters for the gas and air sides must be equal. P.T.H.

A79-42853 # Joint Soviet-American studies in the domain of plasma diagnostics (Sovmestnye Sovetsko-Amerikanskii issledovaniia v oblasti diagnostiki plazmy). A. P. Nefedov and E. M. Shelkov

(Akademiia Nauk SSSR, Institut Vysokikh Temperatur, Moscow, USSR). In: Low-temperature plasma diagnostics.

Moscow, Izdatel'stvo Nauka, 1979, p. 12-18. 8 refs. In Russian.

A joint Soviet-American project on MHD power generation is being carried out at the High Temperature Institute of the Soviet Academy of Sciences. Plasma diagnostics plays an important role in the project. The Soviet contribution is the measurement of plasma temperature and conductivity in MHD generators, while the American contribution is a diagnostic experiment on the Mark-VI MHD generator. B.J.

A79-42854 # Investigation of plasma electroconductivity on the U-25 facility (Issledovanie elektroprovodnosti plazmy na ustanovke U-25). N. A. Balashov, I. M. Gaponov, A. P. Nefedov, and L. P. Poberezhskii. In: Low-temperature plasma diagnostics.

Moscow, Izdatel'stvo Nauka, 1979, p. 19-23. 5 refs. In Russian.

Results are presented of measurements of plasma conductivity in the channel of the U-25 MHD generator facility. Typical oscillograms of conductivity distribution across the plasma flow to a depth of 220 mm are presented. Results are presented for different types of additive, discharge rates of combustion products, and temperatures. Conductivity is studied as a function of temperature and theoretical and experimental values of conductivity are compared. B.J.

A79-42869 # Study of the thermal inertia of an electrode microarc (Issledovaniia teplovoi inertsi pri elektrodnoi mikroduzi). Iu. I. Isaenkov and L. P. Poberezhskii (Akademiia Nauk SSSR, Institut Vysokikh Temperatur, Moscow, USSR). In: Low-temperature plasma diagnostics. Moscow, Izdatel'stvo Nauka, 1979, p. 133-142. 9 refs. In Russian.

The thermal inertia characteristics of a microarc discharge were investigated by analyzing the frequency dependence of the interelectrode gap impedance and the current and voltage relaxation time. An equivalent circuit representation of the measurement method is described. The method involves superposing the ac probe current on the dc MHD generator current. P.T.H.

A79-42875 # The measurement of plasma electrical conductivity by the electromagnetic transmission method (Izmerenie elektroprovodnosti plazmy metodom elektromagnitnogo prosvechivaniia). F. M. Oberman, G. P. Maliuzhonok, S. I. Kruglyi, A. L. Kolokol'tseva, and Iu. S. Mikhailov (Akademiia Nauk SSSR, Institut Vysokikh Temperatur, Moscow, USSR). In: Low-temperature plasma diagnostics. Moscow, Izdatel'stvo Nauka, 1979, p. 172-178. In Russian.

The direct determination of mean plasma electrical conductivity by the measurement of the change in phase shift of a radio frequency electromagnetic wave as it propagates through the plasma between two coils on different sides is examined. Expressions are derived for the phase shift of an electromagnetic wave as it passes from a vacuum through a medium and out again as a function of the electrical conductivity of each medium. The method and proposed measurement apparatus are illustrated in the measurement of the conductivity of various electrolyte solutions in a simulated magnetohydrodynamic generator channel. From the results of the simulation, it is concluded that the procedure may be feasible for the determination of plasma conductivity in a magnetohydrodynamic channel. A.L.W.

A79-42886 International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2 - Heat transfer in energy conversion, natural convection, combined heat and mass transfer, condensation, and forced convection. Conference sponsored by the National Research Council of Canada, Canadian Society for Chemical Engineering, and Canadian Society for Mechanical Engineering. Washington, D.C., Hemisphere Publishing Corp., 1978. 653 p. In English and French. Price of seven volumes, \$279.

Volume 2 of this conference on heat transfer presents theoretical and experimental studies on heat transfer in energy conversion, natural and forced convection, and condensation. Topics of interest include heat transfer in a cooled diesel injector nozzle, high performance jet condensers for steam turbines, natural convection in liquids with temperature-dependent viscosity, turbulent heat transfer in duct flow, and laminar film condensation with noncondensing gases in tubes. S.D.

A79-42893 Studies of cryogenic liquid boiling in centrifugal acceleration fields. B. I. Verkin, Iu. A. Kirichenko, S. M. Kozlov, and N. M. Levchenko (Akademiia Nauk Ukrainskoi SSR, Fiziko-Tekhnicheskii Institut Nizkikh Temperatur, Kharkov, Ukrainian SSR). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 117-122. 13 refs.

Current rapid progress in cryogenic power engineering has aroused a tremendous interest in heat transfer in cryogenic liquid boiling in the field of centrifugal forces. In this paper, heat transfer and critical heat flux densities are experimentally studied under nucleate boiling of helium and nitrogen in the field of centrifugal forces. The discussion concerns experimental equipment and results, temperature field in liquid, inception of nucleate boiling, heat transfer, and critical heat flux. The increase in heat transfer coefficients with rising gravity levels is found to result from an increase in the liquid pressure at the heater. The quantitative dependence of the critical heat flux density on the relative acceleration is established for helium and nitrogen. S.D.

A79-42894 Effects of nonuniform distribution of the absorber temperature on radiation losses of a flat-plate solar collector (Effets d'une répartition non uniforme de température de l'absorbeur sur les pertes par rayonnement d'un capteur solaire plan). G. Lauriat (Conservatoire National des Arts et Métiers, Paris, France). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 129-134. 6 refs. In French.

The paper presents a method of calculating the forward losses of a flat-plate solar collector, taking into account both the nonuniformity of the absorber temperature and the radiation absorption in the cover. For a given one-dimensional temperature distribution (edge effects neglected), a model is developed which allows calculation of the radiation field at the interfaces and the transient distribution of the two-dimensional temperature of the cover; its optical properties are calculated on the basis of the electromagnetic theory in the semitransparent regions. For the steady-state regime, the results provided by this method are compared to those obtained by the Hottel-Whillier-Bliss methods. S.D.

A79-42895 A reflecting radiation trap for producing higher temperatures in flat-plate solar collectors. J. H. Morehouse (Texas A & M University, College Station, Tex.) and R. I. Vachon (Auburn University, Auburn, Ala.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 135-140. 10 refs.

The paper presents analyses of a proposed reflecting radiation trap as a mechanical means to decrease the effective emissivity of a flat-plate solar collector. The proposed trap involves the incorporation of rectangular channels with serrated walls on the sun side of the flat-plate collector. These channels effectively reduce the surface emissivity by reflecting some of the emitted radiation back onto the emitting surface. Engineering-model traps are analyzed as functions of trap configuration, wall reflectivity and emissivity, insolation, conduction-convection losses, and equilibrium temperatures. The effective absorptivity of the collector is increased, while effective emissivity is decreased. The results indicate that although the trap increases the operating temperatures of flat-plate collectors for a given set of insolation and environmental conditions, the optimum

use of the trapping concept is expected to be in conjunction with sun-tracking collectors. S.D.

A79-42896 On the stability of the natural circulation solar heater. Y. Zvirin, A. Shitzer and A. Bartal-Bornstein (Technion - Israel Institute of Technology, Haifa, Israel). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 141-145, 6 refs.

A theoretical discussion is presented of the stability characteristics of the free convection loop representing the thermosyphonic solar water heater. The system consists of a flat-plate collector, a storage tank and connecting pipes. A one-dimensional model is employed with only one space-coordinate running along the circulation loop. It is assumed that the temperature distributions in the various components of the system are linear and that the flow rate is uniform. Stability of a steady state motion in the system is analyzed by using the linearized stability equations and computing the resulting eigenvalues. It is found that the regular solar heater is stable when there is no energy utilization from the storage tank. There are perturbation modes which decay very slowly and oscillatory modes with period of the order of the time required to circulate the loop. For strong energy utilization the system becomes unstable. (Author)

A79-42897 Dynamic modeling of water- and air-heating solar collectors. C. W. Savery and M. Hofmann (Drexel University, Philadelphia, Pa.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 147-151, 11 refs.

The development, verification with test data, and comparison of first and higher order dynamic models of flat plate solar collector thermal performance are described. Collector models are nodalized by components such as covers, absorber plate and insulation as well as segmented in the flow direction. Typical water- and air-heating commercial collectors are studied. Few node models, in which the major components are lumped, are recommended to provide adequate dynamic response characteristics. Continued and developing interest in the use of collector dynamic models is expected due to the importance of operation during periods of low and varying solar intensity and the prospect of flow control in solar heating systems. (Author)

A79-42898 Analysis of conduction responses during an underground coal gasification experiment. P. J. Hommert (Sandia Laboratories, Albuquerque, N. Mex.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 153-158, 10 refs. ERDA-supported research.

An extensive thermocouple array was fielded in the underground coal gasification experiment in the 9-m thick subbituminous coal seam near Hanna, Wyo. The instrumentation provided thermal data on the process during both reverse combustion linkage and forward gasification. A nonlinear least squares inverse heat conduction analysis was carried out. The results allowed the position of the reverse combustion linkage path to be mapped, and estimates of its size and average temperature to be obtained. For forward gasification, the analysis yielded estimates of the final boundaries established by the burn and characterizations of how the front approached its final position. S.D.

A79-42900 Heat transfer of absorbing evaporator in CDE engine system. N. Isshiki, Y. Maekawa, M. Takeuchi (Tokyo Institute of Technology, Tokyo, Japan), I. Nikai (Ishikawajima-Harima Heavy Industries, Co., Yokohama, Japan), and J. Kamoshida (Shibaura Institute of Technology, Omiya, Japan). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 169-174, 5 refs.

In the concentration difference energy (CDE) system, the energy of a thick aqueous solution of inorganic salt is liberated through the generation of absorption heat due to the difference in the intermolecular force produced in the process of concentration change in the aqueous solution. In this paper, heat transfer experiments are carried out on absorbing evaporators of CDE engine systems which work on enriched aqueous solution of inorganic salts absorbing the engine exhaust steam. Very high absorption heat transfer coefficients are obtained. An empirical correlation of absorption Nusselt number and absorption Reynolds number is derived. It is shown that the high heat transfer coefficient enables the absorbing evaporator to have an overall efficiency greater than 0.8-0.9. S.D.

A79-42908 An interferometric study of the local heat transfer by natural convection in inclined air-filled enclosures. W. M. M. Schinkel and C. J. Hoogendoorn (Delft, Technische Hogeschool, Delft, Netherlands). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 2. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 287-292, 13 refs. Research supported by the Nederlandse Organisatie voor Zuiver-Wetenschappelijk Onderzoek.

A holographic interferometer is used to measure the local heat transfer by natural convection in an inclined air-filled enclosure with isotherm hot and cold walls and adiabatic side walls. The air layer is heated from below. It is shown that at an angle of inclination greater than 40 deg the local Nusselt number is maximum at the lower side and minimum at the upper side of the hot plate. At an angle of inclination less than 30 deg, the local Nusselt number has several maxima and minima at different locations along the hot plate. With decreasing angle of inclination, the local heat transfer decreases at the lower side while it increases at the upper side. Mean Nusselt number increases with decreasing angle of inclination for all Rayleigh numbers considered. S.D.

A79-42930 Simultaneous heat and mass transfer in soil with application to waste heat utilization. H. N. Shapiro (Iowa State University of Science and Technology, Ames, Iowa) and M. J. Moran (Ohio State University, Columbus, Ohio). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 19-24, 17 refs. Research supported by the American Electric Power Service Corp.

Recent interest in the possibility of using power plant cooling water in a buried-pipe network to warm soil for agriculture has given impetus to the study of simultaneous heat and mass transfer in soil. The feasibility of soil warming rests to a large extent upon understanding and controlling the energy and mass transports in the soil surrounding the pipes. The paper focuses on the derivation of the governing equations for heat and mass transfer, on the constitutive relationships describing the transport processes in the porous medium, and on the determination of accurate values for the associated transport coefficients for soil. A brief summary is also presented of the simulation of a soil warming system based upon the transport equations developed as well as a review of key conclusions regarding the feasibility of soil warming for agriculture. (Author)

A79-42937 Dynamic testing of a cryogenic heat pipe/radiator. A. A. Cenker, Jr. (Bell Aerospace Textron, Buffalo, N.Y.), B. E. Nelson, and J. T. Chuvala (Perkin-Elmer Corp., Danbury, Conn.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 105-110, 8 refs.

The objectives of the present study are twofold: (1) to demonstrate the applicability of the Perkin-Elmer Lobar Wick (a composite cryogenic wick) to temperature and power levels higher than those previously tested; and (2) to characterize the dynamic behavior of a cryogenic heat pipe/radiator during start-up and step changes in evaporator power. To this end, an experimental investigation is conducted to determine the dynamic characteristics of two

fixed conductance cryogenic heat pipe/radiators 1.3 and 6.4 m long. Freon-13 and nitrogen filled pipes are considered. The schematically shown Lobar Wick is installed in both pipes. It is demonstrated that a standard heat pipe design can be utilized with nitrogen and Freon-13 over an extremely wide temperature range of at least 74-230 K. Dynamic operating characteristics of the 1.3- and 6.4-m heat pipe/radiators are summarized. S.D.

A79-42938 On the problem of heat transfer in low-temperature heat pipes. J. Asakavicius and V. Eva (Lithuanian Academy of Sciences, Institute of Physical and Technical Problems of Energetics, Kaunas, Lithuanian SSR). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 3. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 111-115. 11 refs.

The processes in metal-screen wicks were observed visually on their internal and near-wall surfaces in a transparent heat pipe with Freon-113 and water. Vapor-filled spaces were noted in poor-contact areas. Heat transfer and critical heat flux densities were measured in a vertical setup with wick of copper and stainless-steel screens, and water, ethyl alcohol and Freon-113 as working fluids. In a comparison with a plain-surface, an enhanced heat transfer was noted in the presence of a wick, up to a certain value of the heat flux, followed by a decrease of the heat transfer for further heating. Both the heat transfer and the critical heat flux are higher for higher efficient conductivities and improved vapor evacuation conditions. A perforated press-screen used to fix the wick at the pipe wall had no significant effects on the heat transfer coefficient, but gave a 20 to 30% decrease in the critical heat flux density. A general relation was derived for the heat transfer. (Author)

A79-42973 International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4 - Process and industrial heat transfer, heat transfer in energy utilization, heat exchangers. Conference sponsored by the National Research Council of Canada, Canadian Society for Chemical Engineering, and Canadian Society for Mechanical Engineering. Washington, D.C., Hemisphere Publishing Corp., 1978. 426 p. In English and French. Price of seven volumes, \$279.

Heat transfer in industrial processes is discussed with consideration given to the heat transfer characteristics of ultra pulse welding, the surface temperatures in electron beam welding cavities, and the transient temperature effects in predicting characteristics of gelling-type crude oils. An experimental investigation of a solid sensible heat thermal storage unit is presented together with other problems of thermal storage and heat transfer in energy utilization. Particular attention is given to heat exchangers, and their optimization, design, and performance. Descriptions of compact heat exchanger surface selection methods and regenerator matrices for automotive gas turbines are presented. V.T.

A79-42974 Stratification in thermal storage during charging. B. J. Sliwinski (U.S. Army, Construction Engineering Research Laboratory, Champaign, Ill.), A. R. Mech, and T. S. Shih (Illinois, University, Urbana, Ill.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 149-154. 6 refs. Army-supported research.

A set of dimensionless parameters for predicting the occurrence and degree of thermal stratification in thermal energy storage tanks was identified. An insulated cylindrical tank filled with 300 litres of water was instrumented to allow measurement of the vertical temperature profile for various values of the Peclet and Richardson numbers. The numbers, determined by input temperature, initial tank temperature, flow rate, and tank configuration, were kept constant while the tank was charged and it was found that the position and sharpness of the thermocline were a function of the Peclet and Richardson numbers. A critical value of the Richardson

number was observed, below which stratification does not occur. The difference in performance between stratified and mixed tanks was found to be the rate of heat transfer to the tank. V.T.

A79-42976 Conductive heat transfer from hemispherical, buried tanks with application to solar heating. K. G. T. Hollands, G. M. L. Gladwell, and G. E. Schneider (Waterloo, University, Waterloo, Ontario, Canada). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 161-166. 9 refs.

A79-42981 Regenerator matrices for automotive gas turbines. C. W. Rapley (Sunderland Polytechnic, Sunderland, England). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 201-206. 21 refs.

A recently developed compact passage-type regenerator matrix is described and the heat transfer and pressure-drop performance reported. The heat transfer performance was obtained with the single blow technique using a new test rig, the features of which are discussed. A brief review is made of the evolution of the single blow technique and the various evaluation procedures that can be used. An attempt is made to compare the performance of different types of regenerator matrix using the available published data in a way that is particularly applicable to automotive gas turbine regenerators. This comparison indicates the range of overall matrix parameters that should lead to effective automotive gas turbine regenerator matrix design. (Author)

A79-42983 Design study of coal-fired cored brick regenerative heat exchangers. G. A. Upshaw (Boeing Co., Seattle, Wash.), T. C. Reihman, and H. W. Townes (Montana State University, Bozeman, Mont.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 303-308. 13 refs.

A design study was conducted for cored ceramic brick regenerative heat exchangers for use as air preheaters in coal-fired open cycle magnetohydrodynamic (MHD) power generation systems. Air preheater designs for a 2000 megawatt electrical MHD power plant were analyzed with a computer code that simulated the transient cyclic behavior of the heat exchangers, used local instantaneous ceramic and gas properties, and contained a Nusselt number correlation which included rough surface and entrance effects. The design problem was so formulated that only the reheat inlet velocity and ceramic bed length must be determined to complete design. V.T.

A79-42984 Rippled silica deposits in heat exchanger tubes. T. R. Bott and J. S. Gudmundsson (Birmingham University, Birmingham, England). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 4. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 373-378. 27 refs.

Rippled deposits have been observed during the removal of heat from geothermal water. The effect of the ripples is to produce enhanced heat transfer in the early stages of the fouling process and pressure losses of 170% greater than for equivalent sand grain roughness under similar conditions after 2000 hours. (Author)

A79-43012 International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 6 - Keynote papers. Conference sponsored by the National Research Council of Canada, Canadian Society for Chemical Engineering, and Canadian Society for Mechanical Engineering. Washington, D.C., Hemisphere Publishing Corp., 1978. 518 p. Price of seven volumes, \$279.

Measurement techniques, turbulence models, enhancement, and modeling of heat transfer are discussed. Consideration is given to the

coupled energy transfer and transformation mechanisms across the ocean-atmosphere interface, and to solar collectors and energy storage technologies. Attention is given to the heat transfer problems in nuclear reactors, fires, and food products. Two-phase, two-component heat transfer and postdryout heat transfer are described.

V.T.

A79-43014 Natural convection in porous media and geothermal systems. M. Combarous (Bordeaux I, Université, Talence, Gironde, France). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 45-59. 60 refs.

Experimental and theoretical results concerning the natural and mixed convection in homogeneous and isotropic porous layers saturated with fluid are presented. A description of a sophisticated model used in the analysis of the physical observations on heat transfer is given. Attention is also given to the case where the porous medium is not isotropic. The role of convection in geothermal fields for the case of the usual steam field is discussed considering the overall heat fluxes, temperature distribution, and energy balance. Complimentary information on the influence of free convection in aquifers in natural or artificial situations is given and some aspects of mathematical modeling of real heterogeneous systems are discussed.

V.T.

A79-43016 Enhancement of heat transfer. A. E. Bergles (Iowa State University of Science and Technology, Ames, Iowa). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 89-108. 182 refs.

This review discusses the many techniques which have been shown to enhance convective heat transfer. Applications of the 13 enhancement techniques to the 6 modes of heat transfer are presented. Recent developments, both experimental and analytical, are emphasized and future trends are suggested. The rapid growth of world literature on this subject indicates that enhancement is now a major speciality area in heat transfer research and development. As energy and material shortages become more important factors in the overall cost of thermal systems, industrial utilization of enhancement will increase.

(Author)

A79-43018 An overview of intermediate temperature solar collector and energy storage technology. F. Kreith, J. N. Castle, and C. E. Wyman (Solar Energy Research Institute, Golden, Colo.). In: International Heat Transfer Conference, 6th, Toronto, Canada, August 7-11, 1978, General Papers. Volume 6. Washington, D.C., Hemisphere Publishing Corp., 1978, p. 255-268. 47 refs.

This paper presents a survey of concentrating solar collector and energy storage technology suitable for the mid-temperature range between 370 and 670 K. The thermal performance of generic types of concentrating collectors are compared and the various methods for providing energy storage in the temperature ranges achievable with these collectors are summarized. The objective of this review is to compile the information necessary for the design of solar energy systems in the mid-temperature range and to indicate areas that require additional research to make solar energy economically viable for industrial heat applications.

(Author)

A79-43171 # Heat transfer in a high-power MHD channel (Teploobmen v kanale MGD-generatora Bol'shoi moshchnosti). L. M. Biberman, M. B. Zhelezniak, V. N. Zatepin, G. A. Liubimov, S. A. Medin, and A. Kh. Mnatsakanian. *Akademiia Nauk SSSR, Izvestiia, Mekhanika Zhidkosti i Gaza*, May-June 1979, p. 136-149. In Russian.

The present analysis deals with a linear conduction-type open-cycle MHD generator, employing the combustion products of natural gas in oxygen-enriched air as the working medium. An approximate method (first-approximation) is proposed for calculating the MHD flow and the radiative-convective heat transfer in the generator channel. The method takes the influence of a readily ionizable admixture into consideration.

V.P.

A79-43199 Spacecraft power systems. P. Goldsmith (TRW Electrical Systems Laboratory, Redondo Beach, Calif.). *Quest*, vol. 3, Spring 1979, p. 2-31. 7 refs.

Electric power supplies for spacecraft are reviewed. Primary spacecraft power sources, comprising solar cells and arrays and electric batteries, and the operating principles and fabrication technology of photovoltaic solar cells and arrays and storage batteries, including the nickel-cadmium cell, are discussed and manufacturing processes are illustrated. The design of power regulation and control circuits in solar- and battery-powered spacecraft is considered and possible designs of switching regulators in spacecraft electronic power conversion circuits are presented. Past and current work at TRW on spacecraft solar arrays, battery systems, power subsystem engineering and power processing and conversion is outlined. Future spacecraft power systems are expected to be largely influenced by the Space Shuttle environment, and improvements in the efficiency of solar arrays, nickel-cadmium and nickel-hydrogen batteries, and power control electronics are foreseen.

A.L.W.

A79-43200 Coal desulfurization. R. A. Meyers, L. J. Van Nice, and M. J. Santy (TRW Chemistry and Chemical Engineering Laboratory, Redondo Beach, Calif.). *Quest*, vol. 3, Spring 1979, p. 32-49.

The Meyers process of removing pyritic sulfur from coal chemically before it is burned is presented. The process involves the treatment of crushed coal with an aqueous leaching solution of ferric sulfate which reacts with the coal pyrites to yield soluble ferrous sulfates and elemental sulfur. The solution is drained off and the leaching solution can be regenerated with the production of calcium sulfate (gypsum) and iron oxides; the elemental sulfur remaining in the coal is removed with acetone. A pilot plant has demonstrated the feasibility of the process by reducing the sulfur content of coal to a level consistent with current regulations. The Meyers process has been found to be more economical than flue gas desulfurization for retrofitted or intermittently fired boilers smaller than 500 MW and boilers between 10 and 200 MW. Future applications of the process are assessed.

A.L.W.

A79-43228 The enigma of the eighties: Environment, economics, energy; Proceedings of the Twenty-fourth National Symposium and Exhibition, San Francisco, Calif., May 8-10, 1979. Books 1 & 2. Symposium sponsored by the Society for the Advancement of Material and Process Engineering. Azusa, Calif., Society for the Advancement of Material and Process Engineering (Science of Advanced Materials and Process Engineering Series. Volume 24, Book 1 and Book 2), 1979. Book 1, 858 p.; Book 2, 778 p. Price of two books, \$56.

The proceedings focus on developments in materials technology for energy and environmental problems of the 1980s. Particular consideration is given to nonterrestrial material processing and manufacturing of large space systems, sandwich constructions for aircraft and communications, materials for airline safety, thermal coatings for missile warhead fire protection, and satellite applications of metal matrix composites. Papers are also presented on polyimide/graphite, aluminum/SiC, and fiber reinforced titanium composites, pressure vessel steels for coal gasifiers, environmental effects of composite material processing, adhesive bonding of sandwich structures, heatshield materials for rocket launching systems, and the effects of particulates on solar cells.

A.T.

A79-43283 Measuring dirt on photovoltaic modules. E. B. Murphy and S. E. Forman (MIT, Lexington, Mass.). In: The enigma of the eighties: Environment, economics, energy; Proceedings of the Twenty-fourth National Symposium and Exhibition, San Francisco, Calif., May 8-10, 1979. Book 1. Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1979, p.717-727. 5 refs. Research sponsored by the U.S. Department of Energy.

Techniques for measuring the effects of dirt accumulation on solar photovoltaic (PV) modules are described. The method of

measuring power degradation of PV modules due to dirt, and the use of glass and silicone rubber coverings to protect solar cells from the environment are outlined. The use of the Glossmeter for quantifying dirt buildup on cell front surfaces is discussed, along with its test results in agricultural, suburban, and urban test facilities. Cleaning of PV modules is considered, noting that the Glossmeter can be used to establish the efficiency of cleaning procedures by comparing readings before installation and after a service period. It is concluded that the most significant factor in the degradation of module performance is power loss due to dirt accumulation. A.T.

A79-43294 * **Encapsulation materials for photovoltaic arrays.** C. Coulbert (California Institute of Technology, Jet Propulsion Laboratory, Pasadena, Calif.). In: The enigma of the eighties: Environment, economics, energy; Proceedings of the Twenty-fourth National Symposium and Exhibition, San Francisco, Calif., May 8-10, 1979. Book 2. Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1979, p. 850-865. 6 refs.

As a part of the Low Cost Solar Array Project an encapsulation task has been established to identify, develop, and evaluate new low-cost, long-life encapsulation systems capable of meeting the project cost and performance goals. Low-cost material system candidates have been identified and are being characterized in laboratory and field tests with detailed evaluation of their environmental stability when subjected to temperature cycling, humidity, ultraviolet radiation, dirt, and various other environmental hazards. (Author)

A79-43295 **Structural optimization of SMC line focusing collectors.** R. C. Reuter, Jr. and R. E. Allred (Sandia Laboratories, Albuquerque, N. Mex.). In: The enigma of the eighties: Environment, economics, energy; Proceedings of the Twenty-fourth National Symposium and Exhibition, San Francisco, Calif., May 8-10, 1979. Book 2. Azusa, Calif., Society for the Advancement of Material and Process Engineering, 1979, p. 866-877. 6 refs. Contract No. AT(29-1)-789.

One of the primary structural components of a line focusing solar collector is the reflector support. In this design, it must be a stiff, lightweight, parabolic trough which provides and maintains the correct optical shape for the reflective surface, and protects it from detrimental environmental effects. A viable candidate for the reflector support is a moldable, fiber reinforced, rib stiffened structure which has a low cost, high production rate potential. This paper covers material and analytical considerations made to insure that the sheet molding compound panel design meets specified structural requirements. A detailed analysis is provided and optimization is achieved through steps taken to minimize panel weight. (Author)

A79-43351 **Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints.** Symposium sponsored by the American Meteorological Society. Boston, Mass., American Meteorological Society, 1978. 692 p. \$26.50.

Papers on turbulence, diffusion and air pollution are presented. Major topics include point-source air quality models, point-source air quality studies, geothermal energy and cooling tower studies, wind energy studies, complex terrain diffusion models, complex terrain diffusion studies, the effects of air pollution on visibility, chemical transformations of pollutants, regional air quality studies, urban air quality studies, boundary layer models and experiments, air pollution removal, air quality studies using remote sensing techniques, large-scale and lakeshore air quality studies, the effects of buildings and terrain features on diffusion, and general air quality and diffusion studies. C.K.D.

A79-43370 **Diffusion model validation from ambient air measurements around five coal-fired electrical power plants in Indiana.** K. E. Dowell, R. R. Jacko, and S. C. Shaw (Purdue University, West Lafayette, Ind.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979,

Preprints. Boston, Mass., American Meteorological Society, 1978, p. 109-112. 6 refs.

A79-43371 **Impact of coal fired power plant emissions on the air quality in Huntington Canyon, Utah.** T. C. Spangler, G. R. MacRae, E. L. Hoyind (North American Weather Consultants, Salt Lake City, Utah), and L. E. Newland (Utah Power and Light Co., Salt Lake City, Utah). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 117-121. 6 refs. Research supported by the Utah Power and Light Co.

A79-43372 **The influence of rough terrain on pollutant dispersion and transport from a geothermal power complex.** R. E. Ruff (SRI International Corp., Menlo Park, Calif.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 122-127.

A network of eight monitoring stations has been established to measure hydrogen sulfide concentrations in the mountainous terrain surrounding the Geysers geothermal development area. The concentration measurements, together with meteorological observations (temperature and wind speed and direction) have been used to define specific causes of air quality standard violations at each site. C.K.D.

A79-43373 **The Geysers geothermal area emissions and aerometric data base and air quality analysis.** D. E. Steffen, G. M. Hidy, L. K. Wang, and E. A. Berman (Environmental Research and Technology, Inc., Westlake Village, Calif.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 128-134. Research sponsored by the Geysers Geothermal Environmental Committee.

All available data pertaining to hydrogen sulfide in the California Known Geothermal Resource Area for the period 1976 to 1977 have been collected and analyzed. The observations included ambient H₂S concentrations, wind speed and direction, surface and vertical temperature profiles, precipitation data, and relative humidity in addition to emissions source data such as hourly-average H₂S emission rates, effluent temperature, effluent exit velocity, steam volumetric flow rate and H₂S concentrations, physical release heights and chemical analyses of source samples. The data analysis indicates that the complex terrain in the Geysers-Cob Valley area induces a decoupling of the quasi-gradient flow at the ridge and the wind circulation patterns in the valleys. The airflow in the valleys is mostly influenced by inhomogeneities in surface heating and terrain discontinuities, while winds at the ridge top are apparently driven by meso- or synoptic-scale influences. These phenomena have been related to differences in H₂S levels observed at different monitoring stations. C.K.D.

A79-43376 **Program overview for the Wind Characteristics Program Element of the United States Federal Wind Energy Program.** L. L. Wendell and C. E. Elderkin (Battelle Pacific Northwest Laboratory, Richmond, Wash.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 160-166. 17 refs.

The Wind Characteristics Program Element, a project undertaken to accelerate the development, commercialization and use of wind energy conversion systems by providing wind characteristics data needed to design and evaluate wind energy systems, is described. Attention is directed to four technical program areas: wind characteristics for design and program evaluation, mesoscale wind characteristics development of siting methodologies and wind characteristics relative to the day-to-day operation of wind energy conversion systems. The approaches adopted in each of these four program areas are discussed. C.K.D.

A79-43377 **Estimation of wind characteristics at potential wind energy conversion sites.** C. M. Bhumralkar, F. L. Ludwig, and

R. L. Mancuso (SRI International Corp., Menlo Park, Calif.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 167-172.

A physically based three-dimensional computer model which can provide estimates of wind characteristics needed to assess sites for wind energy conversion systems is presented. The model incorporates the effect of underlying terrain and uses conventional wind information from selected weather stations in the area of the site. The required statistical wind characteristics are estimated from the hourly winds synthesized by the model. A sample application is discussed. C.K.D.

A79-43383 A numerical study of the effects of complex terrain on dynamics of airflow and pollutant dispersion. T. Yamada (Argonne National Laboratory, Radiological and Environmental Research Div., Argonne, Ill.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 213-216. 8 refs. Research supported by the U.S. Department of Energy.

A79-43391 The conversion of SO₂ to sulfate particles in coal fired power plant plumes. A. C. Dittenhoefer and R. G. de Pena (Pennsylvania State University, University Park, Pa.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 287-292. Contract No. E(11-1)-2463.

A79-43429 Application of long-range transport modeling to assess coal development. W. F. Sandusky and D. S. Renné (Battelle Pacific Northwest Laboratories, Richland, Wash.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 555-560. 7 refs. Research supported by the U.S. Department of Energy.

The potential impact on air quality of implementation of the National Energy Plan goal of a two-thirds increase in coal production by 1985 has been assessed for the land area west of 100 deg longitude. The analysis is based on an interpretation of best available control technology, siting scenarios obtained in the Oak Ridge National Laboratory Regional Studies Program, and a regional scale transport, transformation and removal model for SO₂ and sulfates. Results indicate that industrial coal use in southern California and utility coal use in northern Arizona may be constrained by regulations concerning prevention of significant deterioration in SO₂ concentrations. Neither industrial nor utility coal use appears to be limited by Montana and North Dakota state standards for sulfates. Maximum predicted ground-level concentrations of SO₂ and sulfate occur at about 63 km from the source. Most sulfur emissions in the western U.S. will ultimately be deposited in the region. C.K.D.

A79-43430 A practical regional scale air quality simulation model for energy resource development in the four corners area. A. Bass and C. W. Benkley (Environmental Research and Technology, Inc., Concord, Mass.). In: Symposium on Turbulence, Diffusion, and Air Pollution, 4th, Reno, Nev., January 15-18, 1979, Preprints. Boston, Mass., American Meteorological Society, 1978, p. 561-565. 13 refs. Contract No. NOAA-03-6-022-35259.

A79-43448 The NASA budget - Fiscal years 1979-80. D. Baker. *Spaceflight*, vol. 21, Aug.-Sept. 1979, p. 339-348.

The impact of the U.S. federal budget on funding for the Space Shuttle program is discussed. It is contended that many important objectives in space science and technology planned for the 1980s will be frustrated due to tight fiscal constraints being placed on NASA. It is suggested that more money is required to see the Space Shuttle over development hurdles and this will have its own impact on the budgetary format. B.J.

A79-43466 Crystallographic contributions to the energy problem. M. K. Wilkinson (Oak Ridge National Laboratory, Oak Ridge, Tenn.). *Physics Today*, vol. 32, July 1979, p. 32-39. 22 refs. Contract No. W-7405-eng-26.

Four specific areas of crystallographic research are discussed: radiation effects, electrolytes, superconductors, and catalysts. In any radiation environment a complete consideration should be given to the changes in materials properties as a function of time. Electron microscopy plays a central role in these investigations, but the information provided by small-angle scattering is necessary in obtaining a complete understanding of materials defects. Crystallography has made major contributions to the development of solid electrolytes, including complex silver compounds, titanates, niobates, and intercalation layer-type compounds. Attention is drawn to the beta-alumina system. The measurement of phonon dispersion curves by inelastic neutron scattering in the crystallographic investigation on high temperature superconductors is described. Crystallographic studies of the physical properties of heterogeneous catalysts such as gold and platinum are also discussed. V.T.

A79-43469 Garrett ATF 3. M. Hirst. *Flight International*, vol. 115, July 14, 1979, p. 108-112.

The Garrett ATF 3, a turboprop for business jets, is examined. The engine layout is described, which places engine accessories at the rear, and uses eight diffuser boxes to spill core gases into the fan flow. In addition, the engine is a three shaft design in which the fan is driven by the intermediate-pressure turbine. Thus, the engine is believed to be highly efficient in spite of an internal gas path of twice the engine length. Overall losses are considered negligible because the 180 deg bends in the core exhaust only affect 25% of the total mass flow. While the diffuser boxes probably cause backpressure it is noted that they are effective silencers. In the HU-25A Guardian the engine will be rated at 5,050 lb thrust at takeoff. Finally, simplified maintenance is claimed as a result of the unusual layout. M.E.P.

A79-43522 The capital stake in the transition to new energy systems. II (Der Kapitaleinsatz beim Übergang zu neuen Energieversorgungssystemen. II). D. J. Volkmann. *Energiawirtschaftliche Tagesfragen*, vol. 29, June 1979, p. 303, 304, 306 (5 ff.). 76 refs. In German.

The paper discusses the foundations of a model for the restructuring of an economy making the transition from nonrenewable energy to alternative energy systems. Strategies for capital formation needed for the transition are examined. Emphasis is on the conclusions of the study group IIASA. The political questions posed by the energy system changeover are discussed. P.T.H.

A79-43523 Remarks on economic growth and energy requirements (Bemerkungen zu Wirtschaftswachstum und Energiebedarf). W. Müller. *Energiawirtschaftliche Tagesfragen*, vol. 29, June 1979, p. 314-318. 12 refs. In German.

The paper discusses a book entitled 'Decoupling - Economic Growth with More Energy', a book setting forth arguments in favor of nuclear energy. The main point is that economic growth is not necessarily coupled to increased exploitation and exhaustion of nature, which is a premise on which most negative prognoses of economic growth are based. P.T.H.

A79-43524 The influence of increasing energy costs on the economic dimensioning of electrical energy distribution equipment (Der Einfluss steigender Energiepreise auf die wirtschaftliche Bemessung elektrischer Energieverteilungsanlagen). D. Schneller. *Energiawirtschaftliche Tagesfragen*, vol. 29, June 1979, p. 319-323. 6 refs. In German.

On the example of cable equipment and transformers, a technical-economic analysis is carried out in which assumed rising energy costs are taken into account in the dimensioning of electrical energy distribution equipment. It is shown how loss-dependent costs are affected not only by increasing loads but also by increasing energy costs. P.T.H.

A79-43525 Energy management up to the turn of the century - Options and constraints (Energienmanagement bis zur Jahrhundertwende - Optionen und Zwänge). K. Schmitz. *Energie-wirtschaftliche Tagesfragen*, vol. 29, June 1979, p. 327-332. In German.

The paper reviews the energy consumption distribution among primary sources for the FRG in the recent past and present and surveys the prospects for soft coal, brown coal, petroleum, natural gas, nuclear, and renewable energy. This survey serves as a basis for projections of the primary energy requirements structure up to about the year 2010 under given economic assumptions. An energy strategy is proposed according to which in the coming 20-30 years liquid forms of final energy will be phased out in favor of the solid energy carriers. On the primary energy side, petroleum will be strongly cut back, while coal and nuclear energy will increase to allow the projected energy use growth. P.T.H.

A79-43569 High-temperature lifetesting of Al/SiOx/p-Si contacts for MIS solar cells. R. B. Godfrey and M. A. Green (New South Wales, University, Kensington, Australia). *Applied Physics Letters*, vol. 34, June 15, 1979, p. 860, 861. 13 refs.

The major problem to be resolved is whether the improved-performance silicon MIS solar cells can match the long-term stability record of diffused p-n junction cells. Results are presented for one aspect of this instability: the interaction of the overlying metallic layer of the MIS structure with the thin (10-15 Å) insulating layer for the widely used Al/SiOx/p-Si system. It is shown that electrical degradation in the temperature range 270-400°C is governed by an activation energy of 2.56 ± 0.12 eV, indicating that the reduction of the thin oxide layer by Al is the underlying mechanism. Although the MIS contact fails the quickest at high temperatures, extrapolating to lower temperatures indicates that it would outlast conventional cells with Al, Ti/Ag, and at least some cells with Ti/Pd/Ag contacts at any temperature below 200°C. S.D.

A79-43574 Gasification of solid waste - Potential and application of co-current moving bed gasifiers. M. J. Groeneveld and W. P. M. van Swaaij (Twente, Technische Hogeschool Enschede, Netherlands). *Applied Energy*, vol. 5, July 1979, p. 165-178. 14 refs.

A review is given of gasification processes for solid fuels with special emphasis on waste gasification. Although the co-current moving bed gasifier has not been under consideration for a long time, it offers interesting possibilities for waste gasification. Some operational data are given. Two potential applications are discussed - gasification of agricultural waste (maize cobs) in the rural areas of Tanzania and municipal waste gasification. (Author)

A79-43575 Model of the economic efficiency of the exploitation of oil shale in comparison with other mineral sources of energy. B. Gurfel (Negev, University, Beersheba, Israel). *Applied Energy*, vol. 5, July 1979, p. 205-213. 9 refs.

A model for determining the optimal structure of energy production from oil shale is presented. It is based on the following points. A source of energy raw materials is a production complex of an output, processing and utilization of the reserves, and manufacture of by-products. Each type of production has its own characteristics. Direct and feedback production links exist between the existing and newly created production capacities. The model reviews the influence of scientific and technical progress. The model is designed largely for energotechnologic utilization towards the production of essential energy products. The model foresees a discrete variation of power capacity. This way the non-linear function of expense is taken into account. The worked out model makes it possible to ground the rational structure and volume of oil shale use, to draw into production more from its enormous reserves and in this way to favor the relative autonomy of the national energy economy. (Author)

A79-43576 Cretan windmills. M. T. Kanaki and S. D. Probert (Cranfield Institute of Technology, Cranfield, Beds., England). *Applied Energy*, vol. 5, July 1979, p. 215-222. 23 refs.

Tip speed/wind speed ratio calculations are presented for

Cretan-type windmills. The design of Cretan windmills incorporates a near-horizontal shaft with radial spars carrying triangular canvas sails whose bases are towards the circumference of the mill. The edge of each sail is attached to a spar, with the opposite corner secured to an adjacent spar by a cord. The spars are stayed together at the tips and the entire structure is supported by wires connecting the forward extension of the shaft to the outer tips of the spars. These systems are particularly efficient at low wind speeds (less than 5 m/sec) and are easily constructed. They offer a potentially useful source of energy for developing countries. C.K.D.

A79-43591 An efficient optical window for flat-plate solar energy collectors. K. S. Kohli, K. N. Chopra, and R. Hradaynath (Instruments Research and Development Establishment, Dehra Dun, India). *Journal of Optics*, vol. 10, May-June 1979, p. 137-139. 11 refs.

The design features and merits of a modified optical window for use in flat-plate solar energy collectors are described. An optical window composed of two transparent acrylic plastic sheets ribbed together is considered. One of the inner surfaces of the solar window has triangular projection pairs, each of them being separated from the adjacent one by a distance equal to the width of the triangular projection pair at the top. The use of the triangular projection pairs provided in the modified design brings about a significant increase in the efficiency of the solar energy collector at large angles of incidence. Reduced Fresnel reflection losses occur when the solar radiation energy is transmitted through the modified optical window. It is concluded that the modified optical window assures reasonably high overall efficiency of the solar energy collector at and near zero-degree angles of incidence and also improve it at large angles of incidence. S.D.

A79-43615 Prospecting for meteorological energy in Hawaii. C. S. Ramage (Hawaii, University, Honolulu, Hawaii). *American Meteorological Society, Bulletin*, vol. 60, May 1979, p. 430-438. 33 refs. NSF Grant No. AER-76-06696; Contract No. EG-77-G-03-1617.

The necessity for alternative energy sources for Hawaii is discussed and two different methods, wind power and solar energy were tested. Three ways of mapping the wind source were considered: (1) diagnostic numerical modeling, (2) fixed station, and (3) mobile station sampling. It was determined that thermally-induced turbulence brings higher momentum air down to the surface during the day, reducing the slowing effect of friction, whereas greater surface slowing occurs at night, when the frictional force is applied to a shallow surface layer. Hawaii experiences only a moderate annual variation in insolation and on a clear winter day, the sunlight varies only about 33% to that of the midsummer peak. The collection of solar radiation, through 6,000 recently installed flat-plate collectors, should contribute to the energy need. A radiometer network in Oahu and scattered measurements elsewhere, revealed that most trade wind sheltered areas, have as high an insolation as anywhere in the continental U.S. However, more detailed study is necessary to determine how to maximally utilize these energy sources. C.F.W.

A79-43645 Geochemical and geophysical evidence on the geothermal potential of Caledonian granites in Britain. G. C. Brown (Open University, Milton Keynes, Bucks., England), J. Plant, and M. K. Lee (Natural Environment Research Council, Institute of Geological Sciences, London, England). *Nature*, vol. 280, July 12, 1979, p. 129-131. 29 refs. Research supported by the English Electric Co. and Department of Energy.

A79-43676 # Parametric performance analysis of a Darrieus wind turbine system. D. F. Bowles, J. P. Rollins (Clarkson College of Technology, Potsdam, N.Y.), and R. J. Hawks (Tri-State University, Angola, Ind.). *Journal of Energy*, vol. 3, May-June 1979, p. 140-144. 7 refs. Research supported by the Alcoa Foundation.

A steady-state computer simulation was used to evaluate the performance of a small Darrieus rotor aeroturbine loaded by several

different energy conversion devices. For constant speed operation it was found that the generator size must be carefully matched to local wind conditions. Overall system performance can be improved if a variable speed load is used or if variable rotor speed can be provided for a constant speed load. For a range of generator sizes the total power output varies only slightly with generator capacity. (Author)

A79-43677 # Orientation studies for single-axis concentrating collectors. S. Jeter, J. I. Craig, and E. G. Grems (Georgia Institute of Technology, Atlanta, Ga.). *Journal of Energy*, vol. 3, May-June 1979, p. 151-155. 6 refs.

The useful heat gain of a linear single-axis concentrating solar collector is significantly affected by the orientation of the collector. The temporal distribution of the heat output, both diurnally and annually, and the integrated energy output vary with the direction of the collector axis. For a typical insolation sequence, a north to south orientation yields greater annual heat gain while an east to west orientation gives a flatter annual distribution. Selection of the best collector orientation depends on this distribution, the load profile, and the thermal capacitance of the system. The first two factors are considered in the definition of an economic criterion function which is then used to identify the optimum distribution of collectors among all possible orientations. A minimum value indicates a collector array optimized with respect to the characteristics of the load and the overall solar energy system. While applied here to a particular collector type, the method is general and can be used with other configurations. (Author)

A79-43681 # Performance of windmills in a closely spaced array. B. M. Pershing (Aerospace Corp., El Segundo, Calif.). *Journal of Energy*, vol. 3, May-June 1979, p. 185-187. 7 refs.

A model based on momentum theory is developed for windmill performance with slipstream interference. Only the two-rotor interference problem is considered. The windmill performance is obtained from momentum theory with the approach velocity of the blanketed part of the rotor assumed to correspond to the fully developed wake velocity of the upstream windmill. It is shown that wake interference between windmills in a closely spaced array strongly degrades system performance, the power output varying cosine-like from interference-free to fully blanketed operation. Performance improvement results from a more favorable distribution of the kinetic energy of the impinging air over each rotor of the array. S.D.

A79-43682 # Absence of bending effects on solar-receiver-tube fatigue. J. Jones (Sandia Laboratories, Livermore, Calif.). *Journal of Energy*, vol. 3, May-June 1979, p. 187-190. 5 refs. Contract No. AT(29-1)-789.

The system under study may be regarded as a large number (10-20) of discrete supports placed along a thin tube (l/r between 50 and 200) which is heated on one side and free to expand axially. Investigation into the bending of tubes in solar receivers due to one-side heating of the tubes indicate that the supports provided to protect the tubes from wind and earthquake damage effectively prevent any bending from occurring except in regions of high axial thermal gradients. The similarity in results for the beam and bar models suggests that a two-dimensional analysis is adequate as long as the temperature gradients along the tube are small compared to those across the tube. An analytical basis for this conclusion can be found by considering an asymptotic solution to the governing three-dimensional equations in terms of the parameter r/l . The zeroth-order solution is precisely the generalized plane-strain solution, and the higher-order correction terms depend solely on the axial temperature gradients. S.D.

A79-43683 # Free vortices from a wing for wind turbine systems. I. Paraschivoiu and E. Bilgen (Montréal, Ecole Polytechnique, Montreal, Canada). *Journal of Energy*, vol. 3, May-June 1979, p. 190-192. 5 refs.

The effectiveness of vortices behind five types of wing of double trapezoidal forms is studied by considering a Glauert-type distribution of circulation along the wing span. The necessary design

parameters are defined and expressions are derived. It is shown that the output of the classical wing turbine running in a uniform flow field will be increased by a factor of 4-5, if the same turbine runs in the free vortex field generated at the trailing edge of an elliptical wing having a large span with a maximum lift coefficient-to-AR ratio. The results can be utilized to design and build a prototype wind turbine system. S.D.

A79-43718 Long-pulse laser-plasma interactions at 10 to the 12th and 10 to the 15th W/sq cm. B. H. Ripin, R. R. Whitlock, F. C. Young, S. P. Obenschain, E. A. McLean, and R. Decoste (U.S. Navy, Naval Research Laboratory, Washington, D.C.). *Physical Review Letters*, vol. 43, July 30, 1979, p. 350-353. 25 refs. Research supported by the U.S. Department of Energy.

The study examines laser-plasma interaction physics including absorption, plasma formation, heating, plasma expansion, and energy transport for 3-nsec Nd-laser irradiances between 10 to the 12th and 10 to 15th W/sq cm. It is shown that the absorption process is very efficient (over 80%) with minimal Brillouin backscatter and non-thermal electron heating. Low electron temperatures and good axial heat transport yield ion ablation velocities well suited for efficient acceleration of laser fusion pellet shells. This low-irradiance regime has many characteristics favorable to laser fusion. S.D.

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STAR ENTRIES

N79-22163*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**COMPUTERIZED SIMULATION AND PARAMETERIZATION
 OF A NEW HIGH-PERFORMANCE TUBULAR SOLAR
 COLLECTOR**

F. L. Lansing and C. S. Yung *In its* The Deep Space Network
 15 Apr. 1979 p 161-180 refs

Avail: NTIS HC A11/MF A01 CSCL 10A

The second of two reports describing the thermal analysis, computerized performance, simulation and performance sensitivity of a vacuum tube solar collector is presented. The collector is considered a potential candidate for future solar heating and cooling applications. The first report presented details of the two-dimensional thermal model of the solar collector at steady state. In this report the second phase of the study is presented to include the computer simulation and the performance parameterization. Comparison of the simulated performance with the manufacturer's test data show good agreement at wide ranges of operating conditions. The effects of nine major design and performance variables on the performance sensitivity are presented. The results of this parameterization study are supportive in detecting the areas of design modification for performance optimization. G.Y.

N79-22191*# National Aeronautics and Space Administration.
 Lewis Research Center, Cleveland, Ohio.
**RESULTS FROM SYMPOSIUM ON FUTURE ORBITAL
 POWER SYSTEMS TECHNOLOGY REQUIREMENTS**

Sol Gorland 1979 8 p refs To be presented at the 14th
 Intersoc. Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979;
 sponsored by the Am. Chem. Soc.
 (NASA-TM-79125; E-9961) Avail: NTIS HC A02/MF A01
 CSCL 10B

The technology requirements for future orbital power systems were reviewed. Workshops were held in 10 technology disciplines to discuss technology deficiencies, adequacy of current programs to resolve those deficiencies and recommendations for tasks that might reduce the testing and risks involved in future orbital energy systems. Those recommendations are summarized. J.M.S.

N79-22193*# National Aeronautics and Space Administration.
 Lewis Research Center, Cleveland, Ohio.
**AN ECONOMIC ANALYSIS OF A COMMERCIAL AP-
 PROACH TO THE DESIGN AND FABRICATION OF A SPACE
 POWER SYSTEM**

Zimri Putney (Solarex Corp., Rockville, Md.) and Julian Been
 1979 8 p refs Presented at the Conf. on Adv. Technol. for
 Future Space Systems, Hampton, 8-11 May 1979; sponsored
 by AIAA
 (NASA-TM-79153; E-1009) Avail: NTIS HC A02/MF A01
 CSCL 10A

A commercial approach to the design and fabrication of an economical space power system is presented. Cost reductions are projected through the conceptual design of a 2 kW space power system built with the capability for having serviceability. The approach to system costing that is used takes into account both the constraints of operation in space and commercial production engineering approaches. The cost of this power system reflects a variety of cost/benefit tradeoffs that would reduce system cost as a function of system reliability requirements, complexity, and the impact of rigid specifications. A breakdown of the system design, documentation, fabrication, and reliability and quality assurance cost estimates are detailed. J.M.S.

N79-22252# Princeton Univ., N. J. Dept. of Mechanical and
 Aerospace Engineering.

**SOOTING CHARACTERISTICS OF LIQUID POOL DIFFU-
 SION FLAMES M.S. Thesis**

Kenneth W. VanTreuren Jul. 1978 110 p refs

(Contract F49620-78-C-0004)

(AD-A064111; MAE-T-1393; AFIT-C1-79-44T) Avail: NTIS
 HC A06/MF A01 CSCL 21/4

This investigation deals with a liquid fuel diffusion flame and examines the use of the smoke point test as a means of qualitatively measuring the ability of a fuel to produce soot relative to other fuels. Results indicate the necessity of controlling the initial conditions in order to obtain meaningful measurements. This thesis reports a new technique for the smoke point determination that has proved to be more accurate and reproducible than previous methods. Recent studies indicate water addition in a premixed flame chemically suppresses soot formation. As a result, addition of water inside a diffusion flame is a likely direction to pursue. Both water in fuel emulsions and direct steam injection were used in the present investigation. The results indicate a dominant thermal effect and a possible secondary chemical effect of water on soot formation. Blending of various fuel types reveals the domination of an aromatic fuel over an aliphatic when determining a combined smoke point of the mixture. Applying this information to alternative hydrocarbon fuels, the oil shale and coal derived fuels, having a higher percentage of aromatics than conventional fuels, produce soot more readily than their petroleum derived counterparts. Testing of oil shale and conventional fuels supplied by the Air Force verifies this result. GRA

N79-22265# National Bureau of Standards, Washington, D. C.
 Center for Materials Science.

**AN ALGORITHM AND BASIC COMPUTER PROGRAM FOR
 CALCULATING SIMPLE COAL GASIFICATION EQUILIB-
 RIA**

William S. Horton Aug. 1978 81 p refs

(PB-291241/8; NBSIR-78-1509)

Avail: NTIS

HC A05/MF A01 CSCL 07D

Calculation of the equilibrium composition for the gases CH₄, CO, CO₂, H₂, and H₂O is treated by minimizing the Gibbs energy. G. Minimization is constrained by the conservation of chemical elements. With the use of Lagrangian multipliers, the minimum is found by setting the partial derivatives of G with respect to the amount of each substance equal to zero. The resulting non-linear equations are solved iteratively by the Newton-Raphson method. This algorithm is implemented with an interactive computer program written in the BASIC language and named COLGAS. The aim of this work was to provide people who test materials in coal-gasification-like atmospheres an easy way to obtain the equilibrium composition of their gas mixtures. GRA

N79-22318# Hittman Associates, Inc., Columbia, Md.

**SRC (SOLVENT REFINED COAL) SITE, SPECIFIC POL-
 LUTANT EVALUATION. VOLUME 1: DISCUSSION
 Final Report, Nov. 1977 - Sep. 1978**

Homer T. Hopkins, Kathleen M. McKeon, Carolyn R. Thompson,
 and E. Earl Weir Nov. 1978 440 p refs 2 Vol.

(Contract EPA-68-02-2162)

(PB-291495/0; EPA-600/7-78-223a)

Avail: NTIS

HC A19/MF A01 CSCL 21D

The potential environmental effects of the multimedia waste streams from the operation of a standard-size solvent refined coal (SRC-1 and SRC-2) liquefaction facility utilizing 28, 123 Mg of Illinois No. 6 coal per day are assessed. Regulatory standards and guidelines are discussed relative to the emerging synthetic fuels technology. Research needs are identified in terms of SRC technology, monitoring, and environmental sciences. Study results indicate concern for emissions from auxiliary units (cooling towers, boilers, sulfur recovery), fugitive process discharges, solid wastes, leachate contamination of water, polycyclic aromatic hydrocarbon emissions, hazardous wastes, water treatment effectiveness, and interactions within and among media. GRA

N79-22319# Hittman Associates, Inc., Columbia, Md.

SRC (SOLVENT REFINED COAL) SITE-SPECIFIC POL-

LUTANT EVALUATION. VOLUME 2: APPENDICES
Final Report, Nov. 1977 - Sep. 1978

Homer T. Hopkins, Kathleen M. McKeon, Carolyn R. Thompson, and E. Earl Weir Nov. 1978 273 p refs 2 Vol.
 (Contract EPA-68-02-2162)
 (PB-291496/8; EPA-600/7-78-223) Avail: NTIS
 HC A12/MF A01 CSCL 21D

Data are presented in support of a discussion of the environmental effects of the multimedia waste streams from a standard solvent refined coal liquefaction facility. Information on the methodologies involved, including multimedia environmental goals and source analysis methodology is included. The 1977 amendments to the Clean Air, Clean Water, and Hazardous Waste Acts are summarized. GRA

N79-22332# Department of Energy, Washington, D. C. Div. of Industrial Conservation.

INDUSTRIAL ENERGY EFFICIENCY IMPROVEMENT PROGRAM Annual Report

Jun. 1978 35 p
 (DOE/CS-0033/1) Avail: NTIS HC A03/MF A01

The program includes the identification and ranking of the major energy-consuming manufacturing industries (on the basis of 2-digit SIC codes), the establishment of energy efficiency improvement targets for at least the 10 most energy-consuming industries, the identification of major energy-consuming corporations within those industries for the purpose of determining those which must report progress in improving energy efficiency, and the establishment of a reporting system. A tabulation of the final target, at the two-digit SIC level, for the 10 most energy-intensive industries shows for the food and kindred products, 12%; textile mill products, 22%; paper and allied products, 20%; chemical and allied products, 14%; petroleum and coal products, 12%; stone, clay and glass products, 16%; primary metal industries, 9%; fabricated metal products, 24%; machinery, except electrical, 15%; and transportation equipment, 16%. DOE

N79-22401 Pennsylvania State Univ., University Park.
NUMERICAL SIMULATION OF THE COMPACTION-SUBSIDENCE PHENOMENA IN A RESERVOIR FOR TWO-PHASE NONISOTHERMAL FLOW Ph.D. Thesis

Turgay Ertekin 1978 257 p
 Avail: Univ. Microfilms Order No. 7909064

An integrated mathematical model which simulates the behavior of a simultaneously fluid-producing, compacting reservoir and the ground above it is developed. The first part of the mathematical model studies the performance of a closed two-dimensional reservoir which is subjected to hot water injection. Temperature, pressure, and saturation distributions obtained from the first part are used as input to the second part of the mathematical model wherein subsidence-compaction phenomena for a reservoir which is embedded in a semi-infinite poroelastic medium is investigated. The utility of the mathematical model is demonstrated by solving the problem under a variety of field conditions. Results show that hot waterflooding can recover significantly more oil than cold waterflooding. The increase in recovery is directly proportional to the injection rate, injection temperature, and reservoir thickness, and inversely proportional to the thermal conductivity of the overburden and the underburden formations. Dissert. Abstr.

N79-22597# New Mexico Inst. of Mining and Technology, Socorro. New Mexico Bureau of Mines and Mineral Resources.

ESTIMATES OF NEW MEXICO'S FUTURE OIL PRODUCTION INCLUDING RESERVES OF THE 50 LARGEST POOLS

Roy W. Foster, Allan L. Gutjahr, and Glenn H. Warner 1978 59 p refs Prepared in cooperation with State Geologist's Office, Santa Fe, N. Mex.
 (PB-291780/5; CIRC-166) Avail: NTIS HC A04/MF A01 CSCL 08I

This report consists of two parts: (1) an estimate of future oil production for New Mexico, including estimates for the northwest and southeast areas, and (2) an analysis of reserves

of the 50 largest oil pools are included. Production estimates and data are limited to crude oil. GRA

N79-22606# Bureau of Mines, Pittsburgh, Pa. Mining and Safety Research Center.

METHANE DRAINAGE STUDY IN THE SUNNYSIDE COALBED, UTAH Report of Investigations

J. H. Perry, G. N. Aul, and Joseph Cervik 1978 17 p refs
 (PB-289772/6; BM-RI-8323) Avail: NTIS HC A02/MF A01 CSCL 08I

The Bureau of Mines is conducting research to determine the effectiveness of long holes in degasifying an area of the Upper Split of the Lower Sunnyside coalbed at Kaiser Steel Co.'s Sunnyside No. 1 mine. These holes were drilled from the two outside entries of a section that was closed to mining because of excessive methane emissions. Two holes drilled to 430 and 450 feet, respectively, produced initial gas flows of 160,000 and 127,000 cfd. Sixteen days after the completion of the second hole, the total production declined to just over 144,000 cfd. In 9 months of degasification, over 35 MMcf of commercial quality gas has been removed from the coalbed. The combined daily gas flows declined to 106,000 in the 9-month period. The two holes have reduced face emissions by about 40 pct. GRA

N79-22608# Bureau of Mines, Pittsburgh, Pa. Mining and Safety Research Center.

TRACER GAS METHOD FOR MEASURING LEAKAGE THROUGH MINE STOPPINGS Report of Investigations

J. E. Matta, S. D. Maksimovic, and Fred N. Kissell 1978 16 p refs
 (PB-289864/1; BM-RI-8324) Avail: NTIS HC A02/MF A01 CSCL 08I

The Bureau of Mines has developed a tracer gas method for measuring leakage through permanent mine stoppings. In this method, a temporary brattice is erected in the same entry as the leaking permanent stopping. Leakage was evaluated from concentration measurements of a tracer gas introduced into the space between the stopping and brattice. Stopping leakages ranging from 15 cfm to 265 cfm were simulated in an underground coal mine. Leakage values determined by the new method were within 10 pct of the known values. GRA

N79-22613* New Mexico Univ., Albuquerque. Technology Application Center.

HYDROGEN ENERGY. A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, Oct. - Dec. 1978

Oct. 1978 65 p Sponsored by NASA
 (NASA-CR-157962; TAC-H78-004) Avail: NTIS HC A04 for foreign requestors only. Domestic orders, Univ. of New Mexico Tech. Application Center, Albuquerque CSCL 10B

Hydrogen Energy is a continuing bibliographic summary with abstracts of research and projections on the subject of hydrogen as a secondary fuel and as an energy carrier. This update to Hydrogen Energy cites additional references identified during the fourth quarter of 1978. It is the fourth in a 1978 quarterly series intended to provide current awareness to those interested in hydrogen energy. A series of cross indexes are included which track directly with those of the cumulative volume. G.Y.

N79-22614* New Mexico Univ., Albuquerque. Technology Application Center.

SOLAR THERMAL POWER GENERATION. A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, Jul. - Sep. 1978

Jan. 1979 138 p Sponsored by NASA
 (NASA-CR-158004; TAC-STPG-78-003) Avail: NTIS HC A07 for foreign requestors only. Domestic orders, Univ. of New Mexico, Tech. Application Center, Albuquerque CSCL 10B

Bibliographies and abstracts are cited under the following topics: (1) energy overviews; (2) solar overviews; (3) conservation; (4) economics, law; (5) thermal power; (6) thermionic, thermoelectric; (7) ocean; (8) wind power; (9) biomass and photochemical; and (10) large photovoltaics. G.Y.

N79-22615* National Aeronautics and Space Administration. Ames Research Center, Moffett Field, Calif.

INTRODUCTORY ASSESSMENT OF ORBITING REFLECTIONS FOR TERRESTRIAL POWER GENERATION

Kenneth W. Billman, William P. Gilbreath, and Stuart W. Bowen
Apr. 1977 58 p refs
(NASA-TM-73230; A-6996) Avail: NTIS HC A04/MF A01 CSCL 10A

The use of orbiting mirrors for providing energy to ground conversion stations to produce electrical power is shown to be a viable, cost effective and environmentally sound alternative to satellite solar power stations and conventional power sources. This is accomplished with the use of very light weight metal coated polymeric films as mirrors which, after deployment at 800 km, are placed in operational orbit and controlled by solar radiation pressure. Relations are developed showing the influence of a number of parameters (mirror altitude, orbit inclination, period, mirror size and number, and atmospheric effects) on the reflected insolation that may be received by a ground spot as a function of location. Some attractive alternative uses of the reflection are briefly discussed as a beneficial adjuncts to the system.

Author

N79-22616* Boeing Aerospace Co., Seattle, Wash.

SYSTEMS DEFINITION SPACE BASED POWER CONVERSION SYSTEMS: EXECUTIVE SUMMARY Final Report

1977 29 p refs
(Contract NAS8-31628)
(NASA-CR-150209; D180-20309-1) Avail: NTIS HC A03/MF A01 CSCL 10B

Potential space-located systems for the generation of electrical power for use on earth were investigated. These systems were of three basic types: (1) systems producing electrical power from solar energy; (2) systems producing electrical power from nuclear reactors; (3) systems for augmenting ground-based solar power plants by orbital sunlight reflectors. Configurations implementing these concepts were developed through an optimization process intended to yield the lowest cost for each. A complete program was developed for each concept, identifying required production rates, quantities of launches, required facilities, etc. Each program was costed in order to provide the electric power cost appropriate to each concept.

G.Y.

N79-22617* ECON, Inc., Princeton, N. J.

SPACE-BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS STUDY. VOLUME 1: EXECUTIVE SUMMARY Final Report, 30 Sep. 1976 - 31 Mar. 1977

31 Mar. 1977 49 p 5 Vol.
(Contract NAS8-31308)
(NASA-CR-150294; Rept-77-145-1-Vol-1) Avail: NTIS HC A03/MF A01 CSCL 10B

The research concerning space-based solar power conversion and delivery systems is summarized. The potential concepts for a photovoltaic satellite solar power system was studied with emphasis on ground output power levels of 5,000 MW and 10,000 MW. A power relay satellite, and certain aspects of the economics of these systems were also studied. A second study phase examined in greater depth the technical and economic aspects of satellite solar power systems. Throughout this study, the focus was on the economics of satellite solar power. The results indicate technical feasibility of the concept, and provide a preliminary economic justification for the first phase of a substantial development program. A development program containing test satellites is recommended. Also, development of alternative solar cell materials (other than silicon) is recommended.

F.O.S.

N79-22618* Grumman Aerospace Corp., Bethpage, N.Y.

SPACE-BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS STUDY. VOLUME 2: ENGINEERING ANALYSIS Final Report

31 Mar. 1977 264 p refs Prepared for ECON, Inc., Princeton, N. J.
(Contract NAS8-31308)
(NASA-CR-150295) Avail: NTIS HC A12/MF A01 CSCL 10B

The technical and economic feasibility of Satellite Solar Power Systems was studied with emphasis on the analysis and definition of an integrated strawman configuration concept, from which credible cost data could be estimated. Specifically, system concepts for each of the major subprogram areas were formulated, analyzed, and iterated to the degree necessary for establishing an overall, workable baseline system design. Cost data were estimated for the baseline and used to conduct economic analyses. The baseline concept selected was a 5-GW crystal silicon truss-type photovoltaic configuration, which represented the most mature concept available. The overall results and major findings, and the results of technical analyses performed during the final phase of the study efforts are reported.

F.O.S.

N79-22619* Raytheon Co., Wayland, Mass. Equipment Div.
SPACE-BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS STUDY. VOLUME 3: MICROWAVE POWER TRANSMISSION STUDIES Final Report

1 Mar. 1977 195 p refs Prepared for ECON, Inc., Princeton, N. J.
(Contract NAS8-31308)
(NASA-CR-150296) Avail: NTIS HC A09/MF A01 CSCL 10B

The Microwave Power Beam Ionosphere effects and critical interfaces between the Microwave Power Transmission System (MPTS) and the Satellite were studied as part of the NASA/MSFC continuing research on the feasibility of power transmission from geosynchronous orbit. Theoretical predications of ionospheric modifications produced by the direct interaction of the MPTS on the earth's upper atmosphere are used to determine their impact on the performance of the Microwave Power Beam and Pilot Beam System as well as on other RF systems effected by the ionosphere. A technology program to quantitatively define these interactions is developed. Critical interface areas between the MPTS and the satellite which could have a major impact on cost and performance of the power system are identified and analyzed. The areas selected include: use of either a 20 kV versus 40 kV Amplitron, thermal blockage effects of Amplitron heat radiation by the satellite structure, effect of dielectric carry-through structure on power beam, and effect of material sublimation on performance of the Amplitron in Geosynchronous Orbit.

F.O.S.

N79-22620* Little (Arthur D.), Inc., Cambridge, Mass.

SPACE-BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS STUDY. VOLUME 4: ENERGY CONVERSION SYSTEMS STUDIES Final Report

29 Mar. 1977 74 p refs Prepared for ECON, Inc., Princeton, N. J.
(Contract NAS8-31308)
(NASA-CR-150297; C-78127-Vol-4) Avail: NTIS HC A04/MF A01 CSCL 10B

Solar cells and optical configurations for the SSPS were examined. In this task, three specific solar cell materials were examined: single crystal silicon, single crystal gallium arsenide, and polycrystalline cadmium sulfide. The comparison of the three different cells on the basis of a subsystem parametric cost per kW of SSPS-generated power at the terrestrial utility interface showed that gallium arsenide was the most promising solar cell material at high concentration ratios. The most promising solar cell material with no concentration, was dependent upon the particular combination of parameters representing cost, mass and performance that were chosen to represent each cell in this deterministic comparative analysis. The potential for mass production, based on the projections of the present state-of-the-art would tend to favor cadmium sulfide in lieu of single crystal silicon or gallium arsenide solar cells.

F.O.S.

N79-22621* ECON, Inc., Princeton, N. J.

SPACE-BASED SOLAR POWER CONVERSION AND DELIVERY SYSTEMS STUDY. VOLUME 5: ECONOMIC ANALYSIS Final Report

31 Mar. 1977 279 p refs
(Contract NAS8-31308)
(NASA-CR-150298; Rept-77-145-1-Vol-5) Avail: NTIS HC A13/MF A01 CSCL 10B

Space-based solar power conversion and delivery systems are studied along with a variety of economic and programmatic issues relevant to their development and deployment. The costs, uncertainties and risks associated with the current photovoltaic Satellite Solar Power System (SSPS) configuration, and issues affecting the development of an economically viable SSPS development program are addressed. In particular, the desirability of low earth orbit (LEO) and geosynchronous (GEO) test satellites is examined and critical technology areas are identified. The development of SSPS unit production (nth item), and operation and maintenance cost models suitable for incorporation into a risk assessment (Monte Carlo) model (RAM) are reported. The RAM was then used to evaluate the current SSPS configuration expected costs and cost-risk associated with this configuration. By examining differential costs and cost-risk as a function of postulated technology developments, the critical technologies, that is, those which drive costs and/or cost-risk, are identified. It is shown that the key technology area deals with productivity in space, that is, the ability to fabricate and assemble large structures in space, not, as might be expected, with some hardware component technology. F.O.S.

N79-22623*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PRELIMINARY COMPARISON OF THEORY AND EXPERIMENT FOR A CONICAL, PRESSURIZED-FLUIDIZED-BED COAL COMBUSTOR

R. W. Patch Mar. 1979 56 p refs

(NASA-TM-79137; E-9985) Avail: NTIS HC A04/MF A01 CSCL 10A

A published model was used for a comparison of theory with an actual combustor burning caking bituminous coal and using limestone to reduce sulfur dioxide emission. Theoretical bed pressure drop was in good agreement with experiment. The burnable carbon elutriated was not in agreement with experiment, at least partly because the exhaust port was apparently below the transport disengaging height. The observed nitrogen oxides emission rate was about half the theoretical value. There was order-of-magnitude agreement of sulfur dioxide emission rates. Author

N79-22624*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ANALYSIS OF A FUEL CELL ON-SITE INTEGRATED ENERGY SYSTEM FOR A RESIDENTIAL COMPLEX

Stephen N. Simons and William L. Maag (Solar Energy Products Co., Avon Lake, Ohio) 1979 11 p refs Proposed for presentation at the Terrest. Energy Systems Conf., Orlando, Fla., 4-6 Jun. 1979; sponsored by AIAA

(NASA-TM-79161; E-018) Avail: NTIS HC A02/MF A01 CSCL 10B

Declining supplies of domestic oil and gas and the increased cost of energy resulted in a renewed emphasis in utilizing available resources in the most efficient manner possible. This, in turn, brought about a reassessment of a number of methods for converting fossil fuels to end uses at the highest practical efficiency. One of these is the on-site integrated energy system (OS/IES). This system provides electric power from an on-site power plant and recovers heat from the power plant that would normally be rejected to the environment. An OS/IES is potentially useful in any application that requires both electricity and heat. Several OS/IES are analyzed for a residential complex. The paper is divided into two sections; the first compares three energy supply systems, the second compares various designs for fuel cell OS/IES. L.S.

N79-22627*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. **ADVANCED SUBSYSTEMS DEVELOPMENT Semiannual Progress Report, 1 Apr. - 1 Oct. 1978**

Floyd Livingston 15 Nov. 1978 255 p refs Prepared for DOE

(Contract NAS7-100; JPL Proj. 5102-89)

(NASA-CR-158335; SAPR-2; JPL-PUB-79-24;

DOE/JPL-1060-6) Avail: NTIS HC A12/MF A01 CSCL 10B

The concept design for a small (less than 10 MWe) solar thermal electric generating plant was completed using projected 1985 technology. The systems requirements were defined and specified. The components, including an engineering prototype for one 15 kWe module of the generating plant, were conceptually designed. Significant features of the small solar thermal power plant were identified as the following: (1) 15 kWe Stirling-cycle engine/alternator with constant power output; (2) 10 meter point-focusing paraboloidal concentrator with cantilevered cellular glass reflecting panels; (3) primary heat pipe with 800 C output solar cavity receiver; (4) secondary heat pipe with molten salt thermal energy storage unit; (5) electric energy transport system; and (6) advanced battery energy storage capability. G.Y.

N79-22628*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. **ENVIRONMENTAL TESTING OF BLOCK 2 SOLAR CELL MODULES**

J. S. Griffith 1 Jan. 1979 53 p refs Prepared for DOE

(Contract NAS7-100)

(NASA-CR-158521; JPL-PUB-79-5; DOE/JPL-1012-79/1)

Avail: NTIS HC A04/MF A01 CSCL 10A

The testing procedures and results of samples of the LSA Project Block 2 procurement of silicon solar cell modules are described. Block 2 was the second large scale procurement of silicon solar cell modules made by the JPL Low-cost Solar Array Project with deliveries in 1977 and early 1978. The results showed that the Block 2 modules were greatly improved over Block 1 modules. In several cases it was shown that design improvements were needed to reduce environmental test degradation. These improvements were incorporated during this production run. S.E.S.

N79-22629*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. **THERMAL POWER SYSTEMS SMALL POWER SYSTEMS APPLICATION PROJECT: SITING ISSUES FOR SOLAR THERMAL POWER PLANTS WITH SMALL COMMUNITY APPLICATIONS**

H. J. Holbeck and S. J. Ireland 1 Feb. 1979 45 p refs Prepared for DOE

(Contract NAS7-100; JPL Proj. 5103-50)

(NASA-CR-15820; JPL-PUB-78-75-Rev-1) Avail: NTIS HC A03/MF A01 CSCL 10B

The siting issues associated with small, dispersed solar thermal power plants for utility/small community applications of less than 10 MWe are reported. Some specific requirements are referred to the first engineering experiment for the Small Power Systems Applications (SPSA) Project. The background for the subsequent issue discussions is provided. The SPSA Project and the requirements for the first engineering experiment are described, and the objectives and scope for the report as a whole. A overview of solar thermal technologies and some technology options are discussed. S.E.S.

N79-22631*# Xerox Electro-Optical Systems, Pasadena, Calif. **RESEARCH ON ENERGY STORAGE FOR SOLAR THERMAL CONVERSION Final Report**

James L. Clayton Oct. 1978 128 p refs Sponsored by NASA

(Grant NSF C-7522234)

(NASA-CR-159427) Avail: NTIS HC A07/MF A01 CSCL 10A

Thermal energy storage (TES) for solar thermal energy conversion to electric power was studied. Major emphasis was placed on determining the relative merits of latent, sensible, and hybrid latent-sensible storage systems. The thermal energy storage systems evaluated are compatible with 10 MW and 100 MW steam power plants with TES delivery temperature ranges of 400 to 600 F and 900 to 110 F. Also evaluated is a 200 kW - 2000 kW combination total energy system. The initial phase of the study involved a review of storage material thermophysical properties and analysis of the phase change heat transfer mechanism. Analytical studies presented include TES parametric and steam cycle analyses. Design studies were performed and resulting TES system designs are presented. Major TES cost factors are evaluated and summarized. Finally, TES

system reliability, safety, and environmental effects are presented. It is concluded that a hybrid latent-sensible energy storage system is most efficient from a thermodynamic viewpoint for use in conjunction with a steam power plant. Sensible energy storage is presently less costly to implement than latent storage utilizing current heat exchanger technology, however latent energy storage offers high energy density and the potential for future cost reduction. Author

N79-22632*# Rockwell International Corp., Downey, Calif. Space Systems Group.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 3: EXPERIMENTAL VERIFICATION DEFINITION Final Report

Mar. 1979 152 p

(Contract NAS8-32475)

(NASA-CR-161214; SSD-79-0010-3)

Avail: NTIS

HC A08/MF A01 CSCL 10B

An environmentally oriented microwave technology exploratory research program aimed at reducing the uncertainty associated with microwave power system critical technical issues is described. Topics discussed include: (1) Solar Power Satellite System (SPS) development plan elements; (2) critical technology issues related to the SPS preliminary reference configuration; (3) pilot plant to demonstrate commercial viability of the SPS system; and (4) research areas required to demonstrate feasibility of the SPS system. Progress in the development of advanced GaAs solar cells is reported along with a power distribution subsystem.

J.M.S.

N79-22633*# Rockwell International Corp., Downey, Calif. Space Systems Group.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 5: SPECIAL EMPHASIS STUDIES Final Report

G. Hanley Mar. 1979 265 p refs

(Contract NAS8-32475)

(NASA-CR-161215; SSD-79-0010-5)

Avail: NTIS

HC A12/MF A01 CSCL 10B

Specific areas were analyzed and identified as high priority for more in-depth analysis. These areas were: (1) rectenna constructability; (2) satellite constructability; (3) support systems constructability; (4) space environmental analysis, and (5) special end-to-end analyses. Baseline requirements specified coplanar solar blankets and an end mounted antenna, utilizing either GaAlAs solar cells and employing a CR of 2, or Si cells. Several configurations were analyzed. Utilizing the preferred configuration as a baseline, a satellite construction base was defined, precursor operations incident to establishment of orbital support facilities identified, and the satellite construction sequence and procedures developed. Since the baseline specifies sixty instead of one hundred and twenty satellites to be constructed in a thirty year period, mass flow to orbit requirements were revised and new traffic models established. Launch site requirements (exclusive of actual launch operations) in terms of manpower and building space were defined. J.M.S.

N79-22634*# Rockwell International Corp., Downey, Calif. Space Systems Group.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 6: IN-DEPTH ELEMENT INVESTIGATION Final Report

G. Hanley Mar. 1979 97 p refs

(Contract NAS8-32475)

(NASA-CR-161216; SSD-79-0010-6)

Avail: NTIS

HC A05/MF A01 CSCL 10B

Computer assisted design of a gallium arsenide solid state dc-to-RF converter with supportive fabrication data was investigated. Specific tasks performed include: computer program checkout; amplifier comparisons; computer design analysis of GaSa solar cells; and GaAs diode evaluation. Results obtained in the design and evaluation of transistors for the microwave space power system are presented. J.M.S.

N79-22635# Little (Arthur D.), Inc., Cambridge, Mass.

EPRI METHODOLOGY FOR PREFERRED SOLAR SYSTEMS (EMPSS) COMPUTER PROGRAM DOCUMENTATION. USER'S GUIDE

Dan Nathanson and Richard L. Merriam May 1978 275 p refs Sponsored by EPRI

(EPRI Proj. RP549)

(EPRI-ER-771) Avail: NTIS HC A12/MF A01

A computer program was developed by which the behavior of residential solar heating and cooling systems could be analyzed. Unlike several other programs by which buildings and the performance solar heating and cooling equipment can be analyzed, this program is capable of estimating the cost of backup electrical energy from a utility's actual cost of supply, in addition to its rate structures. In its present form the program permits the specification of a wide variety of solar or conventional heating and cooling devices which use electrical energy. Both the thermal loads of the residence and the utility's system-wide load are dependent upon a weather tape which is used in hourly computations extending over one year. Monthly costs of electrical energy are based upon the hourly electrical demand of the residence and the utility's cost-of-supply model. When combined with equipment costs and specified economic parameters, these monthly energy costs are used to predict total life-cycle costs for each system considered, and to show payback periods when compared with conventional equipment. Detailed descriptions of the program elements and of its input and output data streams are provided. DOE

N79-22638# Grumman Aerospace Corp., Bethpage, N.Y.

RECOVERY OF WASTE HEAT FROM PROPELLANT FORCED-AIR DRY HOUSE Final Report, Nov 1978 - Apr. 1978

Joseph Alario, Eugene F. Bezza, and Peter Mullaney Dec. 1978 104 p refs

(Contract DAAA21-77-C-0021)

(AD-A064108; AD-E400264; ARLCD-CR-78029) Avail: NTIS

HC A06/MF A01 CSCL 13/1

This report describes the design, installation, and test evaluation of a heat pipe heat exchanger for a multi-base propellant forced-air dry house for the purpose of recovering heat from the hot air exhausted to the atmosphere during a typical drying operation. Detailed descriptions of the special safety and operating features of the recovery unit are also presented. Evaluation of the unit showed that approximately 62% of the energy used to dry multi-base propellants can be saved by the heat recovery technique employed. Energy/cost saving projections are based upon the installation of similar recovery units at a major Army propellant manufacturing facility such as Radford Army Ammunition Plant. Author (GRA)

N79-22639# Maxwell Labs., Inc., Woburn, Mass.

HIGH POWER MAGNETOHYDRODYNAMIC SYSTEM, VOLUME 1 Final Technical Report, 17 May 1978 - 15 Jun. 1978

D. W. Swallow, O. K. Sonju, D. E. Meader, and H. Becker Jul. 1978 375 p refs

(Contract F33615-76-C-2104; AF Proj. 3145)

(AD-A064796; AFAPL-TR-78-51-Vol-1)

Avail: NTIS

HC A16/MF A01 CSCL 10/2

During this phase a lightweight, high performance hot gas flow train using liquid oxygen and JP-4 was designed and component modeling completed. The magnetohydrodynamic channel/diffuser performance parameters which were used as the design criteria were an output power of 30 MWe, a specific energy extraction of 1.0 MJ/kg, and a specific power density of 200 MWe/cu m. To achieve these performance requirements, the required characteristic velocity efficiency of the combustion system was greater than 99%. During this program a limited amount of development testing was completed using a heat sink combustor and a diagnostics channel. These tests measured the combustor characteristic velocity efficiency and the gas electrical conductivity, as well as pressures, vibrations, and temperatures. The results of the development test program, which verified the design assumptions used to achieve the perform-

ance requirements, were a characteristic velocity efficiency of nearly 99% and a gas electrical conductivity at the magnetohydrodynamic channel inlet of 15 mhos/m. GRA

N79-22640# Maxwell Labs., Inc., Woburn, Mass.
HIGH POWER MAGNETOHYDRODYNAMIC SYSTEM, VOLUME 2 Final Report, 17 May 1976 - 15 Jun. 1978

D. W. Swallom, Otto K. Sonju, D. E. Meader, and H. Becker
 Jul. 1978 316 p refs

(Contract F33615-76-C-2104; AF Proj. 3145)

(AD-A064435; AFAPL-TR-78-51-Vol-2) Avail: NTIS
 HC A14/MF A01 CSCL 10/2

The technical effort discussed in this report covers Phase B of the High Power Magnetohydrodynamic System program, which is a multi-phase program to develop liquid oxygen/liquid hydrocarbon magnetohydrodynamic generators using cesium seed for high performance, portable power supply applications. During this phase a lightweight, high performance hot gas flow train using liquid oxygen and JP-4 was designed and component modeling completed. GRA

N79-22641# State Univ. of New York at Buffalo. Dept. of Chemistry.

FUNDAMENTAL SOLID ELECTRODE STUDIES RELATED TO CORROSION PREVENTION, FUEL CELLS AND BATTERIES Final Report, 1 Aug. 1973 - 15 May 1978

Stanley Bruckenstein May 1978 17 p refs

(Grant AF-AFOSR-2572-74)

(AD-A064554; AFOSR-79-0033TR) Avail: NTIS
 HC A02/MF A01 CSCL 07/4

The study of surface phenomena at solid electrodes related to electrochemical power sources and corrosion processes was the major goal of this research. In particular, three kinds of surface processes were investigated: (1) underpotential metal deposition, (2) neutral species adsorption and (3) insoluble film formation. New electroanalytical and electrochemical techniques were developed specifically for the purpose of studying such surface processes. These techniques made it possible to prepare solutions with extremely low levels of poisoning substances, to distinguish between surface and mass transport controlled processes, and to perform quantitative studies at the micromolar levels of electroactive species that arose in our studies. Underpotential deposition, UPD, of thallium, mercury and silver on gold have resulted in the determination of accurate adsorption isotherms and highly precise determination of the electrosorption valency. Electrosorption valency values for silver show a minimum near a surface coverage of 0.5. No minimum has ever been discovered before. It is believed that this minimum is caused by either a superlattice phenomena and/or a change in double layer structure. Mercury UPD studies established the existence of a spontaneous coulometric process that can produce UPD for open circuited metal electrodes. Carbon monoxide, selected as a model neutral species adsorbate, was shown to exist in a number of adsorbed states on platinum. GRA

N79-22642# Spectrolab, Inc., Sylmar, Calif.

HIGH EFFICIENCY SOLAR PANEL (HESP-2) Final Report
 P. M. Stella, F. M. Uno, and Jay W. Thornhill Aug. 1978
 74 p refs

(Contract F33615-77-C-3108)

(AD-A065009; AFAPL-TR-78-60) Avail: NTIS
 HC A05/MF A01 CSCL 10/2

The objective of this program is to develop space qualified weapon survivable silicon solar cells having a BOL conversion efficiency of 16% at 25 C under AMO illumination. After seven (7) years in the synchronous orbit environment (approximately 3×10^{14} 1 MeV electrons/square centimeter equivalent irradiation) the cells shall not degrade more than 13% in conversion efficiency. The status of the work at this point and the performance of the most recent state-of-the-art cells delivered as representative samples are reported. The results obtained to date indicate that some of the processes chosen for optimization have not proven as fruitful as originally anticipated, while others have demonstrated marked success. The task now is to integrate these various optimizations into an integrated sequence to fabricate cells that meet or surpass the requirements. A list of

possible additional investigations, which appear pertinent and useful to this effort, is included in the section entitled Recommendations. Author (GRA)

N79-22643# Virginia Highway and Transportation Research Council, Charlottesville.

OPPORTUNITIES FOR ENERGY CONSERVATION IN TRANSPORTATION PLANNING AND SYSTEMS MANAGEMENT Final Report, Jul. 1977 - Nov. 1978

Eugene D. Arnold, Jr. Nov. 1978 81 p refs

(PB-291743/3; VHTRC-79-R24; FHWA/VA-79-R24) Avail: NTIS
 HC A05/MF A01 CSCL 13B

A summary is presented based primarily on a literature review, of the energy-savings potential of the elements in the transportation planning process and systems management. Within the scope of long-range planning, the energy aspects of land use and mode of transportation were investigated, whereas for the short range the energy potential of the various transportation systems management strategies were considered. The role of the Virginia Department of Highways and Transportation in energy-saving activities was considered. The report should be value to transportation planners and traffic engineers as an overview of the energy-use characteristics of activities within transportation planning and systems management and as a resource document for detailed energy analyses. GRA

N79-22645# Applied Physics Lab., Johns Hopkins Univ., Laurel, Md.

ENERGY PROGRAMS AT THE JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY Quarterly Report, Apr. - Jun. 1978

Jul. 1978 54 p refs Sponsored by DOE

(PB-290226/0; APL/JHU-EQR-78-2) Avail: NTIS
 HC A04/MF A01 CSCL 10A

The major tasks fall into the following categories: A study of geothermal energy applications in DOE-selected areas of the Atlantic Coastal Plain; regional operational research; the Low-head Hydroelectric Program; the Community Annual Storage Energy System; the status of a development plan for a low-cost flywheel; a landfill methane symposium; and a liquid natural gas safety study. GRA

N79-22646# General Accounting Office, Washington, D. C. Energy and Minerals Div.

TRANSPORTATION ENERGY CONSERVATION IN THE FEDERAL GOVERNMENT

Jan. 1979 15 p

(PB-291697/1; EMD-79-3) Avail: NTIS HC A02/MF A01
 CSCL 10A

As part of a continuing effort to evaluate what the Federal Government is doing to manage its use of energy, the Department of Energy's (DOE's) efforts under the Federal Energy Management Program (FEMP) are reviewed. It is recommended that DOE, through the FEMP, take a more active leadership role in the transportation area by (1) issuing guidance to agencies, (2) investigating and promoting known transportation energy conservation opportunities, and (3) developing a better means of monitoring and evaluating agency energy conservation activities. GRA

N79-22647# General Accounting Office, Washington, D. C. Energy and Minerals Div.

MORE USE SHOULD BE MADE OF ENERGY-SAVING PRODUCTS IN FEDERAL BUILDINGS

Jan. 1979 26 p

(PB-291692/2; EMD-79-11) Avail: NTIS HC A03/MF A01
 CSCL 10A

The many facets of the Federal Energy Management Program are evaluated. The use of available energy-saving technology and several areas where the program could be improved through more effective management are discussed. GRA

N79-22648# Tulsa Univ., Okla. Geophysics Lab.
GEOTHERMAL GROUND NOISE MEASUREMENTS AT ROOSEVELT HOT SPRINGS AND COVE FORT, UTAH
Final Report, 1 Jan. 1976 - 31 Aug. 1978

Stanley J. Laster and Edward J. Douze Sep. 1978 96 p refs
 Sponsored in part by DOE
 (Grant NSF AER-75-04819)
 (PB-291624/5; Contrib-21; NSF/RA-780379) Avail: NTIS
 HC A05/MF A01 CSCL 081

A study to determine the type of noise found around a geothermal reservoir is described. The investigation is based on the fact that noise sources, such as those produced by the reservoir and those that are culture or weather related, can be distinguished by identifying the type of waves produced. Frequency wavenumber spectra with the associated spectra and coherences was the main analysis technique used. Time domain detection methods were also employed in an attempt to find P-waves in the noise. Six element arrays, consisting of six seismometers, were used at both the Roosevelt Hot Springs and Cove Fort areas in Utah to determine the structure of the noise field and types of waves present. Field experiments, instrumentation, and the theory of array processing are described. Experimental results are presented for both geographical areas. Finally, the text presents conclusions, recommendations, references, and numerous tables and figures which include a seismic ground noise data chart, maps of the areas, and frequency-wavenumber spectra. GRA

N79-22661# Aerospace Corp., El Segundo, Calif. Energy and Resources Div.

COMBUSTION MODIFICATION EFFECTS ON NO_x EMISSIONS FROM GAS-, OIL-, AND COAL-FIRED UTILITY BOILERS Final Report, Jul. 1976 - Aug. 1978

Owen W. Dykema Dec. 1978 99 p refs
 (Grant EPA-R-803283-03)
 (PB-289878/1; EPA-600/2-78-217) Avail: NTIS
 HC A05/MF A01 CSCL 13A

The overall objective of the study was to develop from this data: (1) further understanding of the effects of combustion modifications on combustion, and the resulting effects on NO_x emissions; and (2) directly applicable guidelines for the application of combustion modification techniques for the control of NO_x emissions in full-scale operating utility boilers. The report includes: (1) discussion of modeling techniques used to analyze the data; (2) conclusions relative to the sources of NO_x within the furnace; (3) guidelines for NO_x reduction; and (4) an example application of the guidelines. Boiler firing types include single-wall, opposed and tangential configurations. It is included that NO_x emissions are generated, in varying degrees, from conversion of fuel-bound nitrogen (the predominant source), heterogeneous combustion and mixing zone, second-stage mixing zone, and active burner region. Maintaining very fuel-rich initial combustion conditions, holding the initial peak combustion temperature to less than 2050 K, and delaying fuel gasification and mixing until the gas has been cooled somewhat should reduce NO_x emissions from all four main sources. GRA

N79-22662# Washington Univ., Seattle. Center for Quantitative Science in Forestry, Fisheries, and Wildlife
ASSESSING THE IMPACT OF NUCLEAR-POWER PLANTS ON THE ENVIRONMENT Annual Progress Report

Douglas G. Chapman, Dennis P. Lettenmaier, Allyn H. Seymour, Gordon L. Swartzman, and Hannah E. Lawson Feb. 1979 184 p refs
 (PB-290858/0; NUREG-CR-0552; APR-2) Avail: NTIS
 HC A09/MF A01 CSCL 06R

The wide-ranging effects that nuclear-power plants have on the environment are assessed. These include: (1) mortality to fish and other organisms resulting from impingement and entrainment in the cooling system; (2) changes in behavioral and physiological characteristics of aquatic animals by higher temperature present in the discharge plume; and (3) toxic effects of biocides, heavy metals and radionuclides released in the aquatic or atmospheric environment. GRA

N79-22668# Northrop Services, Inc., Research Triangle Park, N. C.

CONVENTIONAL COMBUSTION ON ENVIRONMENTAL ASSESSMENT PROGRAM

Pamela K. Lattimore Dec. 1978 17 p
 (Contract EPA-68-02-2566)
 (PB-291401/8; EPA-600/8-78-021) Avail: NTIS
 HC A02/MF A01 CSCL 138

The objectives, methodology, development, and output of the conventional combustion environmental assessment program on the effect of pollutants from the combustion of fossil fuel is presented. GRA

N79-22891# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

VKI SHORT COURSE ON MAGNETOHYDRODYNAMIC ACCELERATORS AND GENERATORS

John F. Wendt, ed. May 1968 100 p refs Lecture held at Rhode-Saint-Genese, Belgium, 6-10 May 1968
 (VKI-Lecture-Series-8) Avail: NTIS HC 05/MF A01

After an introduction to the fundamental concepts and equations of magnetohydrodynamics (MHD), the performance of various MHD accelerators and generators and their present day problem areas are discussed. Rectangular channel shapes and the axisymmetric models are included. Diagnostic techniques are treated with emphasis on microwave, magnetic, and electric probes. Continuous electrodeless and pulsed accelerators are presented.

N79-22894# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

INSTRUMENTATION

P. C. T. deBoer (Cornell Univ., Ithaca, N. Y.) In its VKI Short Course on Magnetohydrodyn. Accelerators and Generators May 1968 33 p refs
 Avail: NTIS HC A05/MF A01

Plasma diagnostic techniques are treated with emphasis on microwave, magnetic, and electric probes. A probe of the hollow type is a useful instrument for measuring ion density in a flowing plasma. For high charge particle density, the probe functions as a flush probe. Three cases are presented: total collection, sheath thicker than boundary layer, sheath thinner than boundary layer. This allows for the use of the probe over a wide range of ion densities. M.M.M.

N79-22950 Carnegie-Mellon Univ., Pittsburgh, Pa.

THE THERMODYNAMIC PERFORMANCE OF TWO COMBINED CYCLE POWER PLANTS INTEGRATED WITH TWO COAL GASIFICATION SYSTEMS Ph.D. Thesis

Francis Lee Stasa 1978 408 p
 Avail: Univ. Microfilms Order No. 7904883

Thermodynamic models of both an adiabatic and an endothermic coal gasifier integrated with either a waste heat combined cycle or a supercharged boiler combined cycle are developed and incorporated into a FORTRAN computer program. Certain components are added to each configuration in an effort to improve thermodynamic performance, with the effect of each clearly noted. With consideration of the criteria, the station efficiencies for each configuration are within 1 percentage point of each other when flue gas recirculation is used as a means to control the amount of nitric oxide which enters the atmosphere. With a gas turbine inlet temperature of 2000 F and with consideration of the pollution criteria, the configuration employing an adiabatic gasifier and a waste heat system is marginally the best with a station efficiency of only 37 percent. Dissert. Abstr.

N79-22965# Transportation and Economic Research Associates, Inc., Arlington, Va.

REPORT ON CAPITAL REQUIREMENTS FOR TRANSPORTATION OF ENERGY MATERIALS

9 Jun. 1978 263 p refs
 (Contract DOE-CR-03-70307-00)
 (TID-28599) Avail: NTIS HC A12/MF A01

Sufficient data was obtained and organized so that costs of expanding capacity in transportation of energy materials can be determined in a way designed to meet the needs and requirements of the Project Independence Evaluation System (PIES) model. Requirements for capital expenditures are computed for three modes of transport in five computer-based algorithms: oil pipeline investment; gas pipeline investment; rail car and locomotive investment; coal barge and collier investment; and oil barge and tanker investment. Necessary data and assumptions are organized within the context of each algorithm either as a separate data base or written into the program as suits the nature of the mode and the output information obtainable from PIES. DOE

N79-22970# Ender (Richard L.), Anchorage, Alaska.
ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM. BEAUFORT SEA PETROLEUM DEVELOPMENT SCENARIOS: IMPACTS ON ANCHORAGE, ALASKA
 Richard L. Ender, Jan Gehler, Susan Gorski, and Susan Harper Aug. 1978 233 p refs Prepared for Peat, Marwick, Mitchell and Co., Anchorage, Alaska 3 Vol.
 (Contract DI-AA550-CT6-61)
 (PB-291916/5; BLS/YK/TR-78/13; TR-13) Avail: NTIS HC A11/MF A01 CSCL 10A

An impact assessment on the Municipality of Anchorage is presented which encompasses socioeconomic and physical data, as it relates to future population growth and the overriding ramifications of four proposed development scenarios in the Beaufort Sea region. Services are briefly described and, where applicable, quantitative and/or qualitative standards are offered to assess impact. Results of analysis within the community sector include examination of education, public safety, leisure, utilities, housing, health services, social services, transportation, and fiscal requirements. GRA

N79-22971# Dooley (Dennis) and Associates, Anchorage, Alaska.
ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM. BEAUFORT SEA PETROLEUM DEVELOPMENT SCENARIOS: TRANSPORTATION IMPACTS
 Peter Eakland and Dennis Dooley Aug. 1978 175 p refs Prepared for Peat, Marwick, Mitchell and Co., Anchorage, Alaska 3 Vol.
 (Contract DI-AA550-CT6-61)
 (PB-291917/3; BLM/YK/TR-78/20; TR-20) Avail: NTIS HC A08/MF A01 CSCL 10A

The statewide, regional and local transportation impacts of Beaufort Sea petroleum exploration, development, and production are analyzed. Alternative routings for goods and passengers to the area are developed for each mode. Facilities on these routes and carriers using them are described for current conditions. Impacts related to non-OCS (Outer Continental Shelf) development up to the year 2000 are estimated. Individual assessments are given for the petroleum development scenarios for Camden-Canning, Prudhoe Bay-Small, Cape Halkett, and Prudhoe Bay-Large. GRA

N79-22972# Worl Associates, Anchorage, Alaska.
ALASKA OCS SOCIOECONOMIC STUDIES PROGRAM. ASSESSMENT OF CHANGE IN THE NORTH SLOPE, BEAUFORT SEA REGION SOCIOCULTURAL SYSTEMS
 Apr. 1978 115 p refs Prepared for Peat, Marwick, Mitchell and Co., Anchorage, Alaska 3 Vol.
 (Contract DI-AA550-CT6-61)
 (PB-291918/1; BLM/YK/TR-78/22; TR-22) Avail: NTIS HC A06/MF A01 CSCL 10A

The Beaufort Sea Region sociocultural systems, are currently undergoing rapid and intense social, cultural, and economic change. The overall effects on traditional values and sociocultural systems are assessed to determine whether the Inupiat can integrate modernizing influences without disrupting their unique sociocultural system. GRA

N79-23133*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.
THE ROLE OF FUEL CELLS IN NASA'S SPACE POWER SYSTEMS

Julian F. Been 1979 11 p refs To be presented at the 14th Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979 (NASA-TM-79182; E-042) Avail: NTIS HC A02/MF A01 CSCL 22B

A history of the fuel cell technology is presented and compared with NASA's increasing space power requirements. The role of fuel cells is discussed in perspective with other energy storage systems applicable for space using such criteria as type of mission, weight, reliability, costs, etc. Potential applications of space fuel cells with projected technology advances were examined. S.E.S.

N79-23185# National Physical Lab., Teddington (England). Div. of Chemical Standards.

PROSPECTIVE NEEDS FOR PHYSICAL PROPERTY DATA IN THE CHEMICAL AND ALLIED INDUSTRIES DURING THE NEXT DECADE

R. P. Miller Jun. 1978 37 p refs
 (NPL-Chem-84) Avail: NTIS HC A03/MF A01

Summaries are made of developments and trends which are being forecast for these sectors in order to give some perspective to the appraisal in an economic as well as a technical context. The areas considered include petrochemicals, heavy organics, coal, inorganics, metals and alloys, and water management. The type of data likely to be required to promote technical innovations, process optimization, or environmental control are indicated. The increasing importance of computer-based data banks is argued. Author (ESA)

N79-23364* New Mexico Univ., Albuquerque. Technology Application Center.

HEAT PIPE TECHNOLOGY. A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, Oct. - Dec. 1978

31 Dec. 1978 40 p Sponsored by NASA
 (NASA-CR-158005; TAC-HP78-004) Avail: NTIS HC A03 for foreign requestors only. Domestic orders, Univ. of New Mexico, Tech. Application Center, Albuquerque CSCL 20D

This bibliography cites 55 publications on the theory, design, development, fabrication, and testing of heat pipes. Applications covered include solar, nuclear, and thermoelectric energy conversion. A book (in Russian) on low temperature heat pipes is included as well as abstracts when available. Indexes provided list authors, titles/keywords (permuted) and patents. A.R.H.

N79-23481* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

HORIZONTALLY MOUNTED SOLAR COLLECTOR Patent
 Dolphus H. Black, inventor (to NASA) Issued 10 Apr. 1979 9 p Filed 9 Aug. 1977 Supersedes N77-30613 (15 - 21, p 2823)

(NASA-Case-MFS-23349-1; US-Patent-4,148,295;
 US-Patent-Appl-SN-823061; US-Patent-Class-126-270;
 US-Patent-Class-126-271) Avail: US Patent and Trademark Office CSCL 10A

Solar energy is collected by using a vertical deflector assembly, a stationary reflector and a horizontally mounted solar collector. The deflector assembly contains a plurality of vanes which change the direction of the solar energy to the vertical, while constantly keeping the same side of the deflector facing the sun. The vertical rays are then reflected off the stationary reflector and are then absorbed by the collector.

Official Gazette of the U.S. Patent and Trademark Office

N79-23483*# Boeing Aerospace Co., Seattle, Wash.
SYSTEMS DEFINITION SPACE-BASED POWER CONVERSION SYSTEMS Final Report, 8 Jun. 1975 - 30 Nov. 1976
 30 Nov. 1976 95 p refs Prepared in cooperation with Garrett Corp., Los Angeles, and Thermo Electron Corp.
 (Contract NAS8-31628)

(NASA-CR-150268; D180-20309-2) Avail: NTIS HC A05/MF A01 CSCL 10B

Potential space-located systems for the generation of electrical power for use on Earth are discussed and include: (1) systems producing electrical power from solar energy; (2) systems producing electrical power from nuclear reactors; and (3) systems

for augmenting ground-based solar power plants by orbital sunlight reflectors. Systems (1) and (2) would utilize a microwave beam system to transmit their output to Earth. Configurations implementing these concepts were developed through an optimization process intended to yield the lowest cost for each. A complete program was developed for each concept, identifying required production rates, quantities of launches, required facilities, etc. Each program was costed in order to provide the electric power cost appropriate to each concept. A.R.H.

N79-23484*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 1: EXECUTIVE SUMMARY Final Report

G. M. Hanley Mar. 1979 66 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161218; SSD-79-0010-1-Vol-1) Avail: NTIS HC A04/MF A01 CSCL 10B

The Department of Energy (DOE) is currently conducting an evaluation of approaches to provide energy to meet demands in the post-2000 time period. The Satellite Power System (SPS) is a candidate for producing significant quantities of base-load power using solar energy as the source. The SPS concept is illustrated for a solar photovoltaic concept. A satellite, located at geosynchronous orbit, converts solar energy to dc electrical energy using large solar arrays. This study is a continuing effort to provide system definition data to aid in the evaluation of the SPS concept. G.Y.

N79-23485*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 2, PART 1: SYSTEM ENGINEERING Final Report

G. M. Hanley Mar. 1979 257 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161219; SSD-79-0010-2-1-Vol-2-Pt-1) Avail: NTIS HC A12/MF A01 CSCL 10B

Volume 2, Part 1, of a seven volume report is presented. Part 1 encompasses Satellite Power Systems (SPS) systems engineering aspects and is divided into three sections. The first section presents descriptions of the various candidate concepts considered and conclusions and recommendations for a preferred concept. The second section presents a summary of results of the various trade studies and analysis conducted during the course of the study. The third section describes the Photovoltaic Satellite Based Satellite Power System (SPS) Point Design as it was defined through studies performed during the period January 1977 through March 1979. G.Y.

N79-23486*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 2, PART 2: SYSTEM ENGINEERING, COST AND PROGRAMMATICS Final Report

G. M. Hanley Mar. 1979 113 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161220; SSD-79-0010-2-2-Vol-2-Pt-2) Avail: NTIS HC A06/MF A01 CSCL 10B

Volume 2, Part 2, of a seven volume Satellite Power Systems (SPS) report is presented. Part 2 covers cost and programatics and is divided into four sections. The first section gives illustrations of the SPS reference satellite and rectenna concept, and an overall scenario for SPS space transportation involvement. The second section presents SPS program plans for the implementation of PHASE C/D activities. These plans describe SPS program schedules and networks, critical items of systems evolution/technology development, and the natural resources analysis. The fourth section presents summary comments on the methods and rationale followed in arriving at the results documented. Suggestions are also provided in those areas where further analysis or evaluation will enhance SPS cost and programmatic definitions. G.Y.

N79-23487*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 2, PART 2: SYSTEM ENGINEERING, COST AND PROGRAMMATICS, APPENDICES Final Report

G. M. Hanley Mar. 1979 318 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161221; SSD-79-0010-2-2-Vol-2-Pt-2-APP) Avail: NTIS HC A14/MF A01 CSCL 10B

Appendices for Volume 2 (Part 2) of a seven volume Satellite (SPS) report are presented. The document contains two appendices. The first is a SPS work breakdown structure dictionary. The second gives SPS cost estimating relationships and contains the cost analyses and a description of cost elements that comprise the SPS program. G.Y.

N79-23488*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 4: TRANSPORTATION ANALYSIS Final Report

G. M. Hanley Mar. 1979 268 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161222; SSD-79-0010-4-Vol-4) Avail: NTIS HC A12/MF A01 CSCL 10B

Volume 4 of a seven volume Satellite Power Systems (SPS) is presented. This volume is divided into the following sections: (1) transportation systems elements; (2) transportation systems requirements; (3) heavy lift launch vehicles (HLLV); (4) LEO-GEO transportation; (5) on-orbit mobility systems; (6) personnel transfer systems; and (7) cost and programatics. Three appendices are also provided and they include: horizontal takeoff (single stage to orbit technical summary); HLLV reference vehicle trajectory and trade study data; and electric orbital transfer vehicle sizing. G.Y.

N79-23489*# Rockwell International Corp., Downey, Calif. Satellite Systems Div.

SATELLITE POWER SYSTEMS (SPS) CONCEPT DEFINITION STUDY, EXHIBIT C. VOLUME 7: SYSTEM/SUBSYSTEM REQUIREMENTS DATA BOOK Final Report

G. M. Hanley Mar. 1979 118 p refs 7 Vol.

(Contract NAS8-32475)

(NASA-CR-161223; SSD-79-0010-7-Vol-7) Avail: NTIS HC A06/MF A01 CSCL 10B

Volume 7 of the Satellite Power Systems (SPS) Concept Definition Study final report summarizes the basic requirements used as a guide to systems analysis and is a basis for the selection of candidate SPS point design(s). Initially, these collected data reflected the level of definition resulting from the evaluation of a broad spectrum of SPS concepts. As the various concepts matured these requirements were updated to reflect the requirements identified for the projected satellite system/subsystem point design(s). The identified subsystem/systems requirements are defined, and where appropriate, recommendations for alternate approaches which may represent improved design features are presented. A more detailed discussion of the selected point design(s) will be found in Volume 2 of this report. G.Y.

N79-23490*# Solaron Corp., Commerce City, Colo. **SYSTEM DESIGN PACKAGE FOR A SOLAR HEATING AND COOLING SYSTEM INSTALLED AT AKRON, OHIO**

Apr. 1979 73 p Prepared for DOE

(Contract NAS8-32249)

(NASA-CR-161192) Avail: NTIS HC A04/MF A01 CSCL 10A

Information used to evaluate the design of a solar heating, cooling, and domestic hot water system is given. A conventional heat pump provides summer cooling items as the design data brochure, system performance specification, system hazard analysis, spare parts list, and detailed design drawings. A solar system is installed in a single-family dwelling at Akron, Ohio, and at Duffield, Virginia. G.Y.

N79-23491*# Solaron Corp., Commerce City, Colo.
INSTALLATION PACKAGE FOR THE SOLARON SOLAR SUBSYSTEM

Apr. 1979 65 p refs Prepared for DOE
 (Contract NAS8-32249)
 (NASA-CR-161190) Avail: NTIS HC A04/MF A01 CSCL 10A

Information that is intended to be a guide for installation, operation, and maintenance of the various solar subsystems is presented. The subsystems consist of the following: collectors, storage, transport (air handler) and controller for heat pump and peak storage. Two prototype residential systems were installed at Akron, Ohio, and Duffield, Virginia. G.Y.

N79-23492*# Kotin (Allan D.) Economic Consultants, Los Angeles, Calif.

SATELLITE POWER SYSTEM (SPS) RESOURCE REQUIREMENTS (CRITICAL MATERIALS, ENERGY AND LAND)

Allan D. Kotin Oct. 1978 126 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.
 (Contract EG-77-C-01-4024)
 (NASA-CR-158680; HCP/R-4024-02) Avail: NTIS HC A07/MF A01 CSCL 10B

The resource impacts of the proposed satellite power system are evaluated. Three classes of resource impacts are considered separately: critical materials, energy, and land use. The analysis focuses on the requirements associated with the annual development of two five-gigawatt satellites and the associated receiving facilities. M.M.M.

N79-23493*# Environmental Resources Group, Los Angeles, Calif.

SATELLITE POWER SYSTEM (SPS) PUBLIC ACCEPTANCE

Arrie Bachrach Oct. 1978 85 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.
 (Contract EG-77-C-01-4024)
 (NASA-CR-157429; HCP/R-4024-04) Avail: NTIS HC A05/MF A01 CSCL 10B

An outlook on the public acceptability of the solar satellite power system (STS) program is presented and means of monitoring it is described. A discussion of various recent trends that made public acceptance of large scale programs more important are discussed as well as some elements of the public acceptance process. International nongovernmental public acceptance is reported. A discussion is presented of techniques that are available to help clarify and achieve consensus among the conflicting impact perceptions, priorities, and values of interests of those who may be affected by SPS. M.M.M.

N79-23494*# Kotin (Allan D.) Economic Consultants, Los Angeles, Calif.

SATELLITE POWER SYSTEM (SPS). STATE AND LOCAL REGULATIONS AS APPLIED TO SATELLITE POWER SYSTEM MICROWAVE RECEIVING ANTENNA FACILITIES

Allan D. Kotin Oct. 1978 91 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.
 (Contract EG-77-C-01-4024)
 (NASA-CR-157430; HCP/R-4024-05) Avail: NTIS HC A05/MF A01 CSCL 10B

State and local regulation of power plant construction and operation of solar power satellite (SPS) receiving stations is presented. Each receiving antenna station occupies a land area 100-200 km square, receives microwave transmissions from the solar power satellite, and converts them into electricity for transmission to the power grid. The long lead time associated with the SPS and the changing status of state and local regulation dictated emphasis on: generic classification of the types of regulation, and identification of regulatory vectors which affect rectenna facilities. M.M.M.

N79-23495*# Forum for the Advancement of Students in Science and Technology, Washington, D. C.

SATELLITE POWER SYSTEM (SPS) STUDENT PARTICIPATION

Alan Ladwig and Leonard David Oct. 1978 96 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.

(Contract EG-77-C-01-4024)

(NASA-CR-157431; HCP/R-4024-06) Avail: NTIS HC A05/MF A01 CSCL 10B

A assessment of methods which are appropriate to initiate student participation in the discussion of a satellite power system (SPS) is presented. Methods which are incorporated into the campus environment and the on-going learning experience are reported. The discussion of individual methods for student participation includes a description of the technique, followed by comments on its enhancing and limiting factors, references to situations where the method has been demonstrated, and a brief consideration of cost factors. The two categories of recommendations presented are: an outline of fourteen recommendations addressing specific activities related to student participation in the discussion of SPS, and three recommendations pertaining to student participation activities in general. M.M.M.

N79-23496*# PRC Energy Analysis Co., McLean, Va.

POTENTIAL OF LASER FOR SPS POWER TRANSMISSION

Claud N. Bain Oct. 1978 111 p refs Sponsored by NASA and DOE
 (Contract EG-77-C-01-4024)
 (NASA-CR-157432; HCP/R-4024-07) Avail: NTIS HC A06/MF A01 CSCL 10B

Research on the feasibility of using a laser subsystem as an additional option for the transmission of the satellite power system (STS) power is presented. Current laser work and predictions for future laser performance provide a level of confidence that the development of a laser power transmission system is technologically feasible in the time frame required to develop the SBS. There are significant economic advantages in lower ground distribution costs and a reduction of more than two orders of magnitude in real estate requirements for ground based receiving/conversion sites. M.M.M.

N79-23497*# Christol (Carl Q.), Pacific Palisades, Calif.

SATELLITE POWER SYSTEM (SPS) INTERNATIONAL AGREEMENTS

Carl Q. Christol Oct. 1978 282 p refs Sponsored by NASA and DOE Prepared for PRC Energy Analysis Co.
 (Contract EG-77-C-01-4024)
 (NASA-CR-157433; HCP/R-4024-08) Avail: NTIS HC A13/MF A01 CSCL 10B

The political and legal aspects of a satellite power system focusing on the international jurisprudence are presented. M.M.M.

N79-23498*# PRC Energy Analysis Co., McLean, Va.

SATELLITE POWER SYSTEM (SPS) CENTRALIZATION/DECENTRALIZATION

John Naisbitt Oct. 1978 66 p refs Sponsored by NASA and DOE
 (Contract EG-77-C-01-4024)
 (NASA-CR-157434; HCP/R-4024-09) Avail: NTIS HC A04/MF A01 CSCL 10B

The decentralization of government in the United States of America is described and its effect on the solution of energy problems is given. The human response to the introduction of new technologies is considered as well as the behavioral aspects of multiple options. M.M.M.

N79-23499*# PRC Energy Analysis Co., McLean, Va.

SATELLITE POWER SYSTEM (SPS) MAPPING OF EXCLUSION AREAS FOR RECTENNA SITES

James B. Blackburn, Jr. and Bill A. Bavinger Oct. 1978 116 p refs Sponsored by NASA and DOE
 (Contract EG-77-C-01-4024)
 (NASA-CR-157435; HCP/R-4024-10) Avail: NTIS HC A06/MF A01 CSCL 10B

The areas of the United States that were not available as potential sites for receiving antennas that are an integral part of the Satellite Power System concept are presented. Thirty-six variables with the potential to exclude the rectenna were mapped and coded in a computer. Some of these variables exclude a

rectenna from locating within the area of its spatial influence, and other variables potentially exclude the rectenna. These maps of variables were assembled from existing data and were mapped on a grid system. M.M.M.

N79-23500* PRC Energy Analysis Co., McLean, Va.
SATELLITE POWER SYSTEM (SPS) MILITARY IMPLICATIONS
 Claud N. Bain Oct. 1978 49 p refs Sponsored by NASA and DOE
 (Contract EG-77-C-01-4024)
 (NASA-CR-157436; HCP/R-4024-11) Avail: NTIS
 HC A03/MF A01 CSCL 10B

The military implications of the reference satellite power system (SPS) were examined as well as important military related study tasks. Primary areas of investigation were the potential of the SPS as a weapon, for supporting U.S. military preparedness, and for affecting international relations. In addition, the SPS's relative vulnerability to overt military action, terrorist attacks, and sabotage was considered. M.M.M.

N79-23501* PRC Energy Analysis Co., McLean, Va.
SATELLITE POWER SYSTEM (SPS) INTERNATIONAL AGREEMENTS
 Stephen Grove Oct. 1978 83 p refs Sponsored by NASA and DOE
 (Contract EG-77-C-01-4024)
 (NASA-CR-157437; HCP/R-4024-12) Avail: NTIS
 HC A05/MF A01 CSCL 10B

The problems in obtaining international agreements on geostationary orbit availability, microwave frequency allocations and microwave frequency standards for satellites transmitting solar power are considered. The various U.S. policy options, strategies and time frames with respect to key issues are analyzed. M.M.M.

N79-23502* PRC Energy Analysis Co., McLean, Va.
SATELLITE POWER SYSTEM (SPS) FINANCIAL MANAGEMENT SCENARIOS
 Herbert E. Kierloff Oct. 1978 65 p refs Sponsored by NASA and DOE
 (Contract EG-77-C-01-4024)
 (NASA-CR-157438; HCP/R-4024-13) Avail: NTIS
 HC A04/MF A01 CSCL 10B

The factors involved in the evaluation of the Satellite Power System's (SPS) feasibility and in SPS financing and management are presented. Areas for further research are also enumerated. M.M.M.

N79-23503* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
TECHNO-ECONOMIC PROJECTIONS FOR ADVANCED SMALL SOLAR THERMAL ELECTRIC POWER PLANTS TO YEARS 1990-2000
 T. Fujita, R. Manvi, E. J. Roschke, N. El-Gabalawi, G. Herrera, T. J. Kuo, and K. H. Chen 15 Nov. 1979 166 p refs Prepared for DOE
 (Contract NAS7-100; JPL Proj. 5102-99)
 (NASA-CR-158519; JPL-PUB-79-28; DOE/JPL-1060-4) Avail: NTIS HC A08/MF A01 CSCL 10B

Advanced technologies applicable to solar thermal electric power systems in the 1990-200 time-frame are delineated for power applications that fulfill a wide spectrum of small power needs with primary emphasis on power ratings less than 10MW. Projections of power system characteristics (energy and capital costs as a function of capacity factor) are made based on development of identified promising technologies and are used as the basis for comparing technology development options and combinations of these options to determine developmental directions offering potential for significant improvements. Stirling engines, Brayton/Rankine combined cycles and storage/transport concepts encompassing liquid metals, and reversible-reaction chemical systems are considered for two-axis tracking systems such as the central receiver or power tower concept and distributed parabolic dish receivers which can provide efficient low-cost solar energy collection while achieving high temperatures for efficient

energy conversion. Pursuit of advanced technology across a broad front can result in post-1985 solar thermal systems having the potential of approaching the goal of competitiveness with conventional power systems. A.R.H.

N79-23504* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
A NORMATIVE PRICE FOR A MANUFACTURED PRODUCT: THE SAMICS METHODOLOGY. VOLUME 1: EXECUTIVE SUMMARY
 Robert G. Chamberlain 15 Jan. 1979 18 p refs Prepared for DOE 2 Vol.
 (Contract NAS7-100)
 (NASA-CR-158502; JPL-PUB-78-98-Vol-1; DOE/JPL-1012-79/5) Avail: NTIS HC A02/MF A01 CSCL 10A

A summary for the Solar Array Manufacturing Industry Costing Standards report contains a discussion of capabilities and limitations, a non-technical overview of the methodology, and a description of the input data which must be collected. It also describes the activities that were and are being taken to ensure validity of the results and contains an up-to-date bibliography of related documents. Author

N79-23505* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
A NORMATIVE PRICE FOR A MANUFACTURED PRODUCT: THE SAMICS METHODOLOGY. VOLUME 2: ANALYSIS
 Robert G. Chamberlain 15 Jan. 1979 96 p refs Prepared for DOE 2 Vol.
 (Contract NAS7-100)
 (NASA-CR-158503; JPL-PUB-78-98-Vol-2; DOE/JPL-1012-79/5) Avail: NTIS HC A05/MF A01 CSCL 10A

The Solar Array Manufacturing Industry Costing Standards provide standard formats, data, assumptions, and procedures for determining the price a hypothetical solar array manufacturer would have to be able to obtain in the market to realize a specified after-tax rate of return on equity for a specified level of production. The methodology and its theoretical background are presented. The model is sufficiently general to be used in any production-line manufacturing environment. Implementation of this methodology by the Solar Array Manufacturing Industry Simulation computer program is discussed. Author

N79-23507* Solarex Corp., Rockville, Md.
EVALUATION OF THE TECHNICAL FEASIBILITY AND EFFECTIVE COST OF VARIOUS WAFER THICKNESSES FOR THE MANUFACTURE OF SOLAR CELLS Quarterly Progress Report, 30 Sep. 1978 - 15 Jan. 1979
 1979 54 p Prepared for JPL and DOE
 (Contract NAS7-100; JPL-955077)
 (NASA-CR-158588; DOE/JPL-955077-78/3; JPL-9950-43; APR-2) Avail: NTIS HC A04/MF A01 CSCL 10A

Fourteen wafering characterization runs were completed on a wire saw. Wafer thickness/taper uniformity was excellent. Several alternations and design adjustments were made, facilitating saw operation. A wafering characterization cycle was initiated, and is close to completion. A cell characterization cycle was initiated. G.Y.

N79-23508* Lamar Univ., Beaumont, Tex. Dept. of Chemical Engineering.
PROCESS FEASIBILITY STUDY IN SUPPORT OF SILICON MATERIAL TASK 1 Quarterly Technical Progress Report, Jan. - Mar. 1979

Ku-Yen Li, Keith C. Hansen, and Carl L. Yaws Mar. 1979 58 p refs Prepared for JPL and DOE
 (Contract JPL-954343)
 (NASA-CR-158587; ERDA/JPL-954343-79/14; JPL-9950-44; QTPR-14) Avail: NTIS HC A04/MF A01 CSCL 10A

During this reporting period, major activities were devoted to process system properties, chemical engineering and economic analyses. Analyses of process system properties was continued for materials involved in the alternate processes under consideration for solar cell grade silicon. The following property data are reported for silicon tetrafluoride: critical constants, vapor pressure, heat of vaporization, heat capacity, density, surface tension, viscosity, thermal conductivity, heat of formation and Gibb's free

energy of formation. Chemical engineering analysis of the BCL process was continued with primary efforts being devoted to the preliminary process design. Status and progress are reported for base case conditions; process flow diagram; reaction chemistry; material and energy balances; and major process equipment design. Author

N79-23512*# Texas Instruments, Inc., Dallas.
AUTOMATED ARRAY ASSEMBLY, PHASE 2 Annual Progress Report
 Bernard G. Carbajal Feb. 1979 113 p refs Sponsored in part by DOE Prepared for JPL
 (Contracts NAS7-100; JPL-954881)
 (NASA-CR-158599; JPL-9950-48; TI-03-79-15;
 DOE/JPL-954881-79/4) Avail: NTIS HC A06/MF A01 CSCL 10A

The solar cell module process development activities in the areas of surface preparation are presented. The process step development was carried out on texture etching including the evolution of a conceptual process model for the texturing process; plasma etching; and diffusion studies that focused on doped polymer diffusion sources. Cell processing was carried out to test process steps and a simplified diode solar cell process was developed. Cell processing was also run to fabricate square cells to populate sample minimodules. Module fabrication featured the demonstration of a porcelainized steel glass structure that should exceed the 20 year life goal of the low cost silicon array program. High efficiency cell development was carried out in the development of the tandem junction cell and a modification of the TJC called the front surface field cell. Cell efficiencies in excess of 16 percent at AM1 have been attained with only modest fill factors. The transistor-like model was proposed that fits the cell performance and provides a guideline for future improvements in cell performance. Author

N79-23513*# Aerospace Corp., El Segundo, Calif.
LOW COST SOLAR ARRAY PROJECT: COMPOSITION MEASUREMENTS BY ANALYTICAL PHOTO CATALYSIS Quarterly Report, 1 Jan. - 31 Mar. 1979
 David G. Sutton, Luis Galvan, James Melzer, and Raymond F. Heidner, III 1979 16 p refs Sponsored in part by DOE Prepared for JPL
 (Contracts NAS6-100; JPL-955201)
 (NASA-CR-158598; DOE/JPL-955201-78/1; JPL-9950-49;
 QR-2) Avail: NTIS HC A02/MF A01 CSCL 10A

The applicability of the photon catalysis technique for effecting composition analysis of silicon samples is discussed. A detector for the impurities Al, Cr, Fe, Mn, Ti, V, Mo and Zr is evaluated. During the first reporting period Al, Cr, Fe, and Mn were detected with the photon catalysis method. The best fluorescence lines to monitor and determine initial sensitivities to each of these elements by atomic absorption calibration were established. In the course of these tests vapor pressure curves for these four pure substances were also mapped. Ti and Si were detected. The best lines to monitor were catalogued and vapor pressure curves were determined. Attempts to detect vanadium were unsuccessful due to the refractory nature of this element and the limited temperature range of the evaporator. M.M.M.

N79-23515*# Sensor Technology, Inc., Chatsworth, Calif.
DEVELOPMENT OF LOW-COST, HIGH ENERGY-PER-UNIT-AREA SOLAR CELL MODULES Final Report
 Gregory T. Jones, Sanjeev Chitre, and Sang S. Rhee Apr. 1978 150 p refs Sponsored in part by DOE Prepared for JPL
 (Contracts NAS7-100; JPL-954605)
 (NASA-CR-158556; ERDA/JPL-954605-78/5; JPL-9950-52)
 Avail: NTIS HC A07/MF A01 CSCL 10A

The development of two hexagonal solar cell process sequences, a laserscribing process technique for scribing hexagonal and modified hexagonal solar cells, a large through-put diffusion process, and two surface macrostructure processes suitable for large scale production is reported. Experimental analysis was made on automated spin-on anti-reflective coating equipment and high pressure wafer cleaning equipment. Six hexagonal solar cell modules were fabricated. Also covered is a detailed theoretical analysis on the optimum silicon utilization by modified hexagonal solar cells. G.Y.

N79-23517*# Motorola, Inc., Phoenix, Ariz. Semiconductor Group.

METALLIZATION OF LARGE SILICON WAFERS Final Report

Robert A. Pryor [1978] 138 p Sponsored by NASA and DOE Prepared for JPL
 (Contract JPL-954689)
 (NASA-CR-158575; Rept-2344/4; DOE/JPL-954689-78/4;
 JPL-9950-57) Avail: NTIS HC A07/MF A01 CSCL 10A

A metallization scheme was developed which allows selective plating of silicon solar cell surfaces. The system is comprised of three layers. Palladium, through the formation of palladium silicide at 300 C in nitrogen, makes ohmic contact to the silicon surface. Nickel, plated on top of the palladium silicide layer, forms a solderable interface. Lead-tin solder on the nickel provides conductivity and allows a convenient means for interconnection of cells. To apply this metallization, three chemical plating baths are employed. G.Y.

N79-23519*# Pennsylvania Univ., Philadelphia. School of Engineering.

ANALYSIS AND EVALUATION OF PROCESSES AND EQUIPMENT IN TASKS 2 AND 4 OF THE LOW-COST SOLAR ARRAY PROJECT Quarterly Report, Aug. - Oct. 1978

M. Wolf Jan. 1979 46 p refs Sponsored by NASA and DOE Prepared for JPL
 (Contract JPL-954796)

(NASA-CR-158580; DOE/JPL-954796-78/5; JPL-9950-62)
 Avail: NTIS HC A03/MF A01 CSCL 10A

To facilitate the task of objectively comparing competing process options, a methodology was needed for the quantitative evaluation of their relative cost effectiveness. Such a methodology was developed and is described, together with three examples for its application. The criterion for the evaluation is the cost of the energy produced by the system. The method permits the evaluation of competing design options for subsystems, based on the differences in cost and efficiency of the subsystems, assuming comparable reliability and service life, or of competing manufacturing process options for such subsystems, which include solar cells or modules. This process option analysis is based on differences in cost, yield, and conversion efficiency contribution of the process steps considered. G.Y.

N79-23523*# Motorola, Inc., Phoenix, Ariz. Semiconductor Group.

THE ESTABLISHMENT OF A PRODUCTION-READY MANUFACTURING PROCESS UTILIZING THIN SILICON SUBSTRATES FOR SOLAR CELLS Quarterly Technical Report, 1 Feb. - 31 Mar. 1979

R. A. Pryor 1979 18 p Prepared for JPL and DOE
 (Contract JPL-955328; Proj. 2364)

(NASA-CR-158566; DOE/JPL-955328-79/1; QTR-1;
 Rept-2364/1) Avail: NTIS HC A02/MF A01 CSCL 10A

During the months of February and March, work towards the goals of the contract were started as scheduled. The first shipment of thin substrates were received and wafer processing was initiated. The objective of the contract is to investigate, develop and characterize the methods for establishing a production-ready manufacturing process which utilizes thin silicon substrates for solar cells. The thin substrates to be manufactured are three inches diameter, p-type Czochralski wafers of approximately 1 Ohm cm resistivity. The wafers are prepared by sawing directly to thickness of 8 mils and 5 mils. To ensure removal of residual saw damage, most substrates are chemically etched to final thicknesses of 7 mils and 4 mils. The thin substrates are used to fabricate solar cells by standard processing techniques. G.Y.

N79-23527*# Motorola, Inc., Phoenix, Ariz.

THE DEVELOPMENT OF A METHOD OF PRODUCING ETCH RESISTANT WAX PATTERNS ON SOLAR CELLS Quarterly Technical Report, 17 Jan. - 31 Mar. 1979

E. Pastirik 1979 13 p Prepared for JPL and DOE
 (Contract JPL-955324; Proj. 2365)

(NASA-CR-158563; DOE/JPL-955324-79/1; DRD-SE-4;
 QTR-1; Rept-2365/1) Avail: NTIS HC A02/MF A01 CSCL 10A

The first quarter of a one-year program to investigate the production of patterned etch resistant wax coatings on solar cell substrates by printing is reported. Master molds for printing plates were produced for the plates. The resist wax is being studied to determine its relevant physical properties. A printing device is currently in design, and material costs are being compiled as first step in a cost analysis task. All phases of the project are proceeding according to schedule. No specific phases are yet completed. G.Y.

N79-23534# Engineering Supervision Co., Los Angeles, Calif.
NATIONAL ENERGY PEAK-LEVELING PROGRAM (NEPLP)
 Jun. 1978 181 p
 (Contract EY-76-C-03-1152)
 (HCP/W-1152-01) Avail: NTIS HC A09/MF A01

Progress is reported on the project to perform energy audits in five diverse building complexes in the central-city areas of downtown Los Angeles: Occidental Center, United California Bank, The May Company, The Southern California Gas Company, and the Department of Water and Power. The project has demonstrated the willingness of individual building owners and their operating personnel to mutually join--without a directive--in a cooperative energy-conservation venture under the anticipated computer-directed control. The technical expertise to support the ownership-management objectives has been demonstrated. Moreover, it has been shown that personnel at the operating level can function as a team with a high degree of mutual cooperation under centralized technical cooperative direction. DOE

N79-23537# Association Aeronautique et Astronautique de France, Paris.

ADAPTATION FOR THE ECONOMY OR ADAPTATION FOR ENERGY CONSERVATION [ADAPTATION POUR L'ECONOMIE OU ADAPTION POUR L'ECONOMIE D'ENERGIE]

P. Lecomte 1977 44 p refs In FRENCH Presented at the 13th Intern. Aeron. Congr., Paris, 2-3 Jun. 1977

(AAAF-NT-77-23; ISBN-2-7170-0448-3) Avail: NTIS HC A03/MF A01; CEDOCAR, Paris FF 25 (France and EEC) FF 29 (others)

Text from an opening lecture at the Paris Aeronautical International Congress, June 1977, is presented. The central argument is that optimization of aircraft design can not be based only on energy conservation, other factors being important. Several graphs are given referring to various technical and economical situations. The conclusions are that sound aircraft design must take into account factors or market competitiveness and passenger's preferences, and that some logical energy conserving ideas are, for instance modern turboprop for mach 0.6/0.7; short/medium distances straight wing jet for mach 0.75; innovation either in systems or structure, permitting weight reduction, and optimization of air traffic for minimal energy expenditure. Author (ESA)

N79-23539# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

TRACER EXPERIMENTS IN THE FIELD. EXAMPLE OF APPLICATION FOR THE DETERMINATION OF SLIDE LEVELS FOR STACK DISCHARGES AT A NUCLEAR RESEARCH ESTABLISHMENT

H. C. Bultynck *In its Atmospheric Turbulence and Diffusion and Their Influence on Air Pollution* May 1973 27 p (For primary document see N79-23538 14-45)
 Avail: NTIS HC A14/MF A01

A discussion is presented on the diffusion theory for the predetermination of working limits for stack discharges of a nuclear research center. This aim can only be achieved by means of tracer releases and, whenever possible, the releases have to be performed in the same operational conditions as imposed by the prevailing circumstances of the actual discharges in the atmosphere. Some examples of application of the diffusion theory are presented. G.Y.

N79-23551# Forest Service, Ogden, Utah.
DRAFT ENVIRONMENTAL STATEMENT OF THE ISLAND PARK GEOTHERMAL AREA, IDAHO, MONTANA, WYOMING

[1979] 176 p refs Original contains color illustrations
 Avail: NTIS HC A09/MF A01

The granting of leases for exploration and possible development of geothermal resources on Federal public land is considered, as authorized by the Geothermal Steam Act of 1970. The purpose of the statement is to present a description of the existing or affected environment, show a range of alternatives for geothermal leasing, and consider the possible effects of implementing a leasing program. The alternatives were developed by an interdisciplinary team of resource specialists using existing and collected data and public involvement. G.Y.

N79-23555* National Aeronautics and Space Administration, Pasadena Office, Calif.

UNDERWATER SEISMIC SOURCE Patent

Lien C. Yang, inventor (to NASA) (JPL) Issued 8 May 1979 4 p Filed 6 Sep. 1977 Sponsored by NASA

(NASA-Case-NPO-14255-1; US-Patent-4,153,134; US-Patent-Appl-SN-830458; US-Patent-Class-181-120; US-Patent-Class-340-12R; US-Patent-Class-181-115) Avail: US Patent and Trademark Office CSCL 08G

Apparatus for generating a substantially oscillation-free seismic signal for use in underwater petroleum exploration, including a bag with walls that are flexible but substantially inelastic, and a pressured gas supply for rapidly expanding the bag to its fully expanded condition is described. The inelasticity of the bag permits the application of high pressure gas to rapidly expand it to full size, without requiring a venting mechanism to decrease the pressure as the bag approaches a predetermined size to avoid breaking of the bag.

Official Gazette of the U.S. Patent and Trademark Office

N79-23710# National Technical Information Service, Springfield, Va.

A DIRECTORY OF COMPUTER SOFTWARE APPLICATIONS: NATURAL RESOURCES AND EARTH SCIENCES Progress Report, 1970 - Dec. 1978

Dec. 1978 151 p
 (PB-288486/4; NTIS/SA-78/18) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 05B

Natural resource and earth science reports that list computer programs and/or their documentation are cited. These software applications pertain to topics such as mining, hydrology, soil and rock properties, earthquake modeling, forestry, remote sensing, cartography, geophysics, coastal zone management, and geothermal systems. The directory contains complete bibliographic data for each report as well as a subject and a corporate author index. GRA

N79-23806* Cornell Univ., Ithaca, N. Y. Dept. of Material Science.

STRUCTURE AND ELECTRICAL ACTIVITY OF PLANAR DEFECTS IN EFG RIBBONS Quarterly Report, 1 Jan. - 31 Mar. 1979

D. G. Ast 15 Apr. 1979 11 p Prepared for JPL and DOE (Contract JPL-954852)

(NASA-CR-158572; DOE/JPL-954852-79/1; QR-1) Avail: NTIS HC A02/MF A01 CSCL 20L

Optical, electron beam induced current (EBIC), and transmission electron microscopy were used to study the structure and electrical activity of planar defects in EFG silicon. What appears to be twin boundaries by both optical microscopy plus etching, and by EBIC are in reality systems of microtwins, some of which are only a few atomic lattice planes thick. The electrical activity of planar defects appears to be correlated with emission of dislocations especially at termination points. Impurity effects may also play a role. Twin boundaries per se appear not to be electrically active. A.R.H.

N79-23836# Societe Bertin et Cie, Plaisir (France).

HIGH SPEEDS AND AEROTRAIN

P. Guienne *In Von Karman Inst. for Fluid Dyn. High Speed Ground Vehicles* 1972 9 p

Avail: NTIS HC A10/MF A01

Economic, technical, and psychological considerations associated with the choice of an operating speed for a transportation system are discussed. Propulsion efficiency, safety, and yaw and pitch stability are emphasized. It is indicated that the air cushion and braking systems of the Aerotrains meet the requirements for satisfactory operation. J.M.S.

N79-23886# Office of Naval Research, London (England). **EUROPEAN SCIENTIFIC NOTES, VOLUME 32, NUMBER 4** Aubrey W. Pryce, ed. and Victoria S. Hewitson, ed. Apr. 1978 43 p (AD-A065399; ESN-32-4) Avail: NTIS HC A03/MF A01 CSCL 05/2

Contents: Overview of Remote Sensing Program in the USSR Academy of Sciences; The 'Water Lens' Makes a Big Splash in Norway; Wave Power, UK--Britannia Rules the Waves; More Energy from the Sea...And Why the Sea is Boiling Hot; Electrical Engineering at Birmingham; Defects in Stuttgart; The Belgian Center for Corrosion Study; Numerical Analysis and Software Development at NPL; Yet Another Example of Changing Times; Acoustics, the Theater, the Performer, and the Audience; Laser Spectroscopy at Edinburgh; Fluid Mechanics at the Universidad Politecnica de Madrid; If Hebrew Can Be Typed Without Much Training, Can English Be Far Behind; Computer Models for Personnel Selection; and Evidence for a New Biological Rhythm Is Emerging. GRA

N79-24024*# Parker (Lee W.), Inc., Concord, Mass. **PLASMA SHEATH EFFECTS AND VOLTAGE DISTRIBUTIONS OF LARGE HIGH-POWER SATELLITE SOLAR ARRAYS** Lee W. Parker. In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 341-357 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

Knowledge of the floating voltage configuration of a large array in orbit is needed in order to estimate various plasma-interaction effects. The equilibrium configuration of array voltages relative to space depends on the sheath structure. The latter dependence for an exposed array is examined in the light of two finite-sheath effects. One effect is that electron currents may be seriously underestimated. The other is that a potential barrier for electrons can occur, restricting electron currents. A conducting surface is assumed on the basis of a conductivity argument. Finite-sheath effects are investigated. The results of assuming thin-sheath and thick-sheath limits on the floating configuration of a linearly connected array are studied. Sheath thickness and parasitic power leakage are estimated. Numerically computed fields using a 3-D code are displayed in the thick-sheath limit. G.Y.

N79-24026*# National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala. **MAGNETIC SHIELDING OF LARGE HIGH-POWER-SATELLITE SOLAR ARRAYS USING INTERNAL CURRENTS** Lee W. Parker (Parker (Lee W.), Inc., Concord, Mass.) and William A. Oran. In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 376-387 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

Present concepts for solar power satellites involve dimensions up to tens of kilometers and operating internal currents up to hundreds of kiloamperes. A question addressed is whether the local magnetic fields generated by these strong currents during normal operation can shield the array against impacts by plasma ions and electrons (and from thruster plasmas) which can cause possible losses such as power leakage and surface erosion. One of several prototype concepts was modeled by a long narrow rectangular panel 2 km wide and 20 km long. The currents flow in a parallel across the narrow dimension (sheet current) and along the edge (wire currents). The wire currents accumulate from zero to 100 kiloamp and are the dominant sources. The

magnetic field is approximated analytically. The equations of motion for charged particles in this magnetic field are analyzed. The ion and electron fluxes at points on the surface are represented analytically for monoenergetic distributions and are evaluated. G.Y.

N79-24027*# Grumman Aerospace Corp., Bethpage, N.Y. **ENVIRONMENTAL INTERACTION IMPLICATIONS FOR LARGE SPACE SYSTEMS** E. Miller, W. Fischbein, M. C. Stauber, and P. K. Suh. In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 388-407

Avail: NTIS HC A99/MF A01 CSCL 22B

Large Space Systems (LSS) comprise a new class of spacecraft, the design and performance of which may be seriously affected by a variety of environmental interactions. The special concerns associated with spacecraft charging and plasma interactions from the LSS designer's viewpoint are addressed. Survivability of these systems under combined solar U.V., particle radiation and repeated electrical discharges is of primary importance. Additional questions regard the character of electrical discharges over very large areas, the effects of high current/voltage systems and magnitude of induced structural disturbances. A concept is described for a large scale experiment platform. G.Y.

N79-24028*# Rice Univ., Houston, Tex. Dept. of Space Physics and Astronomy. **SPACE ENVIRONMENTAL EFFECTS AND THE SOLAR POWER SATELLITE**

John W. Freeman, David Cooke, and Patricia Reiff. In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 408-418 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

Some preliminary findings regarding the interactions between the space plasma at GEO and the Marshall Space Flight Center January 1978 baseline Satellite Power Systems (SPS) design are summarized. These include the following: (1) the parasitic load will be dominated by photoelectrons and will amount to about 34 MW; (2) material of higher conductivity than kapton should be used for the solar reflector substrate and the solar cell blanket support material; (3) the satellite structure and solar reflector should be tied electrically to midpoint voltage of each solar cell array; and (4) tests should be run on the proposed solar cell cover glass material (synthetic sapphire) to determine if breakdown is expected. G.Y.

N79-24029*# Boeing Aerospace Co., Seattle, Wash. **PLASMA PARTICLE TRAJECTORIES AROUND SPACECRAFT PROPELLED BY ION THRUSTERS** H. B. Liemohn, R. L. Copeland, and W. M. Leavens. In NASA. Lewis Res. Center Spacecraft Charging Technol., 1978 1979 p 419-436 refs

Avail: NTIS HC A99/MF A01 CSCL 22B

The thruster plasma is assumed to be described by a collimated energetic beam and a cloud of ionized thermal propellant produced by charge-exchange. A simple adiabatic model is used to describe the expansion of these neutral plasmas away from the source. As the pressure falls, shielding currents dissipate, and the geomagnetic field takes control of the particles. In low earth orbit, it is concluded that the vehicle easily outruns its thruster plasma. At geosynchronous altitude, the local electric fields around high voltage surfaces collect return current from the thermal plasma that appears to be limited only by the available space charge. Results appropriate to proposed electric propulsion missions and the solar power satellite are presented and operational considerations are discussed. Author

N79-24071# Ball Bros. Research Corp., Boulder, Colo. Aerospace Systems Div. **OUTGASSING TESTS OF FIBER-EPOXY COMPOSITE MATERIALS** H. C. Poehlmann. Feb. 1979 48 p (Contract EY-76-C-04-0789) (SAND-78-7075) Avail: NTIS HC A03/MF A01

Twelve throughput-type outgassing tests were performed on samples of six different fiber-epoxy composite materials that are of prospective use in energy-storage flywheels. One set of tests was run with the material samples at room ambient temperatures (about 30 C) while the other set was run with the samples at 66 C. The test equipment used and the test results are discussed. DOE

N79-24095 Oklahoma Univ., Norman.

ANALYSIS OF COKE COMBUSTION DURING IN-SITU OIL RECOVERY Ph.D. Thesis

Christian Olufemi Ozomaro 1978 154 p
 Avail: Univ. Microfilms Order No. 7911160

A nonlinear optimization technique was developed for analyzing the data from coke combustion studies and the results indicate that the power law type rate expression does not adequately describe the coke combustion kinetics. Two combustion regimes were observed: an early period characterized by simultaneous carbon and hydrogen combustion and a later period characterized by pure carbon combustion. Analysis of atomic hydrogen carbon ratio further substantiate the above observation and conclusion. At temperature above 950 F, the coke combustion process was observed as being controlled by mass transfer while at temperatures below 900 F, the process is controlled by chemical kinetics. Regardless of the temperature regime under consideration, both mass transfer and reaction control mechanisms do exist. Parameters like coke concentration, combustion temperature, gas flow rate effect oxygen utility efficiency can explained in terms of the coke reaction kinetics. Dissert. Abstr.

N79-24120# Canada Inst. for Scientific and Technical Information, Ottawa (Ontario).

RATE OF DESULFURIZATION FROM LIQUID IRON AND IRON ALLOYS WITH HYDROGEN

Mitsutako Hino, Shiro Ban-ya, and Tasuku Fuwa 1979 31 p
 refs. Transl. into ENGLISH from Tetsu to Hagane (Japan), vol. 62, no. 1, 1976 p 33-42
 (NRC/CNR-TT-1930; ISSN-0077-5606) Avail: NTIS
 HC A03/MF A01

The desulfurization of liquid iron mainly taking place between slag-metals was investigated to provide a basic study on gas-liquid reactions at high temperatures. The reaction rates were not determined by the conventional liquid iron sampling method, but by following the extent of reaction per unit time by continuously measuring the quantity of hydrogen sulfide produced during the reaction. The effects of the reaction gas's flow rate, the reaction temperature, stirring of the liquid iron, the partial pressure of the reaction gas, and alloying elements on the rate of desulfurization were determined. The alloying elements studied included carbon, silicon, and phosphorus, which increase the activity of sulfur in liquid iron, vanadium, which decreases the activity; and oxygen, which is the surface active element. Reaction mechanisms of these systems are discussed. Author

N79-24143# National Technical Information Service, Springfield, Va.

CORROSION OF STAINLESS STEEL, VOLUME 2. A BIBLIOGRAPHY WITH ABSTRACTS Progress Report. 1977 - Mar. 1979

William E. Reed Mar. 1979 135 p Supersedes NTIS/PS-78/0233; NTIS/PS-77/0183; NTIS/PS-76/014
 (NTIS/PS-79/0208/3; NTIS/PS-78/0233; NTIS/PS-77/0183; NTIS/PS-76/0114) Avail: NTIS HC \$28.00/MF \$28.00 CSCI 11F

Research on stainless steel composition, mechanical properties, structure, and testing in relation to corrosion is cited. Nuclear reactor materials are studied as well as corrosion in coal gasification plants, rocket propellant tanks, underwater cables, batteries, and geothermal systems. GRA

N79-24171 Utah Univ., Salt Lake City.

HYDROLYSIS OF COAL DERIVED LIQUIDS AND RELATED MODEL COMPOUNDS Ph.D. Thesis

Ramasamy Ramakrishnan 1978 160 p
 Avail: Univ. Microfilms Order No. 7902481

The development of a new process for upgrading of coal liquids and other heavy oils into liquids and/or C2-C4 gaseous products involving hydrolysis in the temperature range of 500 to 650 C and hydrogen pressures of 120 to 2250 psig is presented. Three types of starting feeds, including model compounds, were employed: (1) normal paraffins, in particular, n-hexadecane; (2) polycyclic naphthenes, in particular, decalin; and (3) coal liquids and other heavy oils or solids. A special reactor for hydrolysis under quantitative conditions was designed and constructed. The change in product composition as a function of feedstock chemical structure, and of experimental conditions, was investigated, and mechanistic aspects of the thermal hydrocracking process elucidated. Dissert. Abstr.

N79-24172*# Boeing Commercial Airplane Co., Seattle, Wash.
DESIGN AND EVALUATION OF AIRCRAFT HEAT SOURCE SYSTEMS FOR USE WITH HIGH-FREEZING POINT FUELS Final Report

A. J. Pasion NASA May 1979 53 p refs
 (Contract NAS3-20815)
 (NASA-CR-159568; D6-48097) Avail: NTIS
 HC A03/MF A01 CSCI 21D

The objectives were the design, performance and economic analyses of practical aircraft fuel heating systems that would permit the use of high freezing-point fuels on long-range aircraft. Two hypothetical hydrocarbon fuels with freezing points of -29 C and -18 C were used to represent the variation from current day jet fuels. A Boeing 747-200 with JT9D-7/7A engines was used as the baseline aircraft. A 9300 Km mission was used as the mission length from which the heat requirements to maintain the fuel above its freezing point was based. J.A.M.

N79-24176# Lehigh Univ., Bethlehem, Pa.

DEVELOPMENT OF A MODULAR SOFTWARE SYSTEM FOR THE DYNAMIC SIMULATION OF COAL CONVERSION PLANTS Quarterly Report, Apr. - Jun. 1978

William E. Schiesser, F. P. Stein, S. H. Johnson, H. S. Caram, G. R. Dissinger, and K. L. Chen Jul. 1978 31 p refs
 (Contract EX-76-C-01-2338)
 (FE-2338-10) Avail: NTIS HC A03/MF A01

Development of the general DSS/2 code continued in three directions: (1) a manual was completed for the application of DSS/2 to partial differential equations (PDEs) in cylindrical and spherical coordinates, (2) alternative methods for approximating the first-order spatial derivatives in PDEs describing flow-through systems, e.g., tubular reactions, heat exchangers are programmed and given a preliminary test, and (3) the Harwell and Yale sparse matrix codes are being implemented on the Lehigh computer in case and implicit integrator based on sparse matrix methods is later required. New coding was added to the methanator model to readjust the reaction conversions if one or more of the reactants are consumed in a reactor. The new steady-state condition was confirmed to be accurate by an independent program. Simulation of the hydrogen plant was initiated. The first unit to be modeled is the steam reformer in which reactions are limited not by kinetics but by heat transfer. DOE

N79-24180# Midwest Research Inst., Golden, Colo. Solar Energy Research Inst.

DENSIFIED BIOMASS: A NEW FORM OF SOLID FUEL

Tom Reed and Becky Byrant Jul. 1978 44 p refs
 (Contract EG-77-C-01-4042)

(SERI-35) Avail: NTIS HC A03/MF A01

Biomass is an economically and environmentally attractive fuel, but it is often difficult to collect, store, ship, and use. Densifying biomass to a specific gravity of 1.0 eliminates most of these fundamental problems and produces a uniform, clean, stable fuel: densified biomass fuel or DBF. Before conversion to DBF, raw biomass residues generally require preparation: the separation of noncombustibles from combustibles, especially for solid municipal waste; milling; and drying. About 5% of the energy content in raw biomass can be expended in preparation and 1% to 3% in densification. In its densified form, biomass can be burned in standard equipment with reduced emissions and increased heat release and thermal efficiency. DOE

N79-24181# Catalytic, Inc., Wilsonville, Ala.
SOLVENT REFINED COAL (SRC) PROCESS: OPERATION OF SOLVENT REFINED COAL PILOT PLANT Quarterly Technical Progress Report, Jan. - Mar. 1978

H. E. Lewis, W. H. Weber, G. B. Usnick, W. R. Hollenack, H. W. Hooks, and R. G. Boykin Jul. 1978 166 p refs
 (Contract EX-76-C-01-2270)

(FE-2270-34) Avail: NTIS HC A08/MF A01

Operating conditions and test results obtained at the Solvent Refined Coal pilot plant in Wilsonville, Alabama, during the first quarter of 1978 are summarized. Indiana V coal processing was continued. The yield of SRC was 46% of the MAF coal for a product containing 0.6 to 0.7 wt % sulfur. Process solvent was generated in consistently greater quantities than required to sustain steady-state operation. Tests confirming the high rate of Indiana V conversion at short residence times were completed. Coal conversion of 93% was attained at the slurry preheater when most of the hydrogen gas was bypassed around the preheater. Temperatures up to 850 F at the preheater outlet were investigated. A series of mineral residue separation experiments was conducted. DOE

N79-24182# Fluor Engineers and Constructors, Inc., Irvine, Calif.
CONCEPTUAL DESIGN FOR ADVANCED COAL LIQUEFACTION COMMERCIAL PLANT Final Report

Jun. 1978 73 p refs

(Contract EX-76-C-01-2251)

(FE-2251-52) Avail: NTIS HC A04/MF A01

A revised refining sequence employing catalytic cracking was developed for comparison to the base case which used hydrocracking. The refining sequence includes a distillate hydrotreater, a hydrocracker, a naphtha hydrotreater, a catalytic reformer, and an alkylation unit in addition to the catalytic cracking unit. Complete material and utility balances were developed and a capital cost estimate was prepared. Economics were then developed. The cost of gasoline produced in the alternate case was about \$0.50 per barrel greater than the cost of gasoline in the base case. But this may not be conclusive in view of the approximate nature of the study. A purchased power case was considered in which a large block of electric power in purchased for operating the plant along with 91 MW produced internally. The combined cycle gas turbine power plant included in the base case was eliminated and gas used to fire these turbines was converted to additional by-product SNG. DOE

N79-24183# Bechtel Corp., San Francisco, Calif.
ANALYSIS OF COAL HYDROGASIFICATION PROCESSES Quarterly Technical Progress Report, 1 Dec. 1977 - 28 Feb. 1978

Apr. 1978 60 p refs

(Contract EF-77-A-01-2565)

(FE-2565-13) Avail: NTIS HC A04/MF A01

Data from 15 recent Rocketdyne hydrogasification tests with subbituminous and bituminous coals and 24 Rocketdyne partial liquefaction tests with bituminous coals were entered into the computerized data base. Data from 17 recent Cities Service hydrogasification tests with subbituminous coal were also entered into the data base. The Cities Service, Rocketdyne, and PERC data bases were expanded to include values for the following: carbon selectivity to BTX (Cities Service); carbon selectivity to methane, ethane, and BTX (Rocketdyne); and gas velocity, gas residence time, and carbon selectivity to gas, methane, and ethane (PERC). Semiempirical correlations for predicting overall carbon conversion and carbon conversion to gas, methane, CO, and CO₂ were fitted to the Cities Service and Rocketdyne subbituminous coal data. The analysis showed that the Cities Service bench-scale reactor and the Rocketdyne 1/4-ton/hr reactor give similar values of overall carbon conversion and carbon conversion to gaseous products under comparable operating conditions. DOE

N79-24184# Institute of Gas Technology, Chicago, Ill.
PIPELINE GAS FROM COAL-HYDROGENATION: IGT HYDROGASIFICATION PROCESS, PROJECT 9000 Quarterly Report, 1 Jan. - 31 Mar. 1978

Aug. 1978 147 p refs

(Contract EX-76-C-01-2434)

(FE-2434-29; QR-7) Avail: NTIS HC A07/MF A01

Tests were conducted, with HYGAS pilot plant, to obtain data on the operating conditions necessary for high char conversion at high throughputs, using Illinois No. 6 bituminous coal. Three tests, numbers 68, 69, and 70, were conducted. In addition, three major modifications were made to the HYGAS reactor to improve the operation of the steam-oxygen gasifier and to decrease fines loss from the reactor. After Test 70, the Institute of Gas Technology (IGT) made three modifications to the plant. A new, six-nozzle, steam-oxygen sparger design was installed, the 339 valve was relocated, and the installation of double-screening equipment in the coal feed area was completed. Other plant turnaround activities were also conducted during the time required for the above modifications. HYGAS personnel continued to supply Procon, Inc., with data to aid them in their design of a commercial/distribution HYGAS plant. IGT also made suggestions to Procon concerning the commercial plant reactor design. DOE

N79-24185# Colorado School of Mines, Golden. Dept. of Chemical and Petroleum Refining Engineering.

CLEAN SOLID AND LIQUID FUELS FROM COAL Quarterly Progress Report, Jan. - Mar. 1978

J. H. Gary, J. O. Golden, R. M. Baldwin, R. L. Bain, and D. W. Dickerhoof 15 May 1978 97 p refs

(Contract EX-76-C-01-2047)

(FE-2047-8) Avail: NTIS HC A05/MF A01

Three additional continuous coal conversion experiments were completed. The number of experiments was limited because of a vendor strike which delayed delivery of pump parts. The preliminary experiments to test system operability and to test for pressure and temperature effects were completed, and initial data reduction was finished. Conversion data for runs performed to date are presented. All experimental work has been completed for the CO-Steam catalyst investigation; the majority of the analytical workup is also complete. The results are summarized. In addition, preliminary results of conversion modelling are presented. Two extended experimental runs, each approximately 45 hours in duration, were completed on the HDN screening program. These runs comprise 2 of 3 runs needed to test for mass transfer effects in the trickle-bed reactor system before kinetic experiments can be made. DOE

N79-24186# City Coll. of the City Univ. of New York.
IMPROVED TECHNIQUES FOR GASIFYING COAL Quarterly Report, 1 Jan. - 31 Mar. 1978

Robert A. Graff, J. Yerushalmi, and A. LaCava Apr. 1978 65 p refs

(Contract EX-76-S-01-2340)

(FE-2340-7; QR-7) Avail: NTIS HC A04/MF A01

Experiments were conducted in the modified 6-inch system to delineate the boundary between the turbulent regime and the transport states, including the fast fluidized bed regime. The results throw light on the phenomenon of choking. Fluidization experiments in the fast bed regime with a relatively coarse solid confirm that to achieve stable and smooth fast fluidization of a coarse solid requires correspondingly higher gas velocities and associated solid rates. The yields of light hydrocarbon are not affected by their continued contact with char in the vapor residence zone. Sixty-nine to 85% of the nitrogen and 84 to 91% of the sulfur in Ireland Mine coal are converted to volatile species during flash hydrogenation at 100 atm. The method of injecting tracer gas to serve as an internal standard was validated against the standard technique in which the tracer is premixed with the reaction gas. DOE

N79-24187# Purdue Univ., Lafayette, Ind.
SYSTEMS STUDIES OF COAL CONVERSION PROCESSES USING A REFERENCE SIMULATOR Quarterly Report, 1 Apr. - 30 Jun. 1978

G. V. Reklaitis, M. K. Sood, S. Raghavan, Y. Soni, B. W. Overturf, J. R. Ford, P. Buchanan, Wj Weide, Jr., C. R. Wilkinson, and J. Boo Aug. 1978 84 p refs

(Contract EX-76-C-01-2275)

(FE-2275-8) Avail: NTIS HC A05/MF A01

The simulation model of the hydrotreating process section successfully tested the integrated operation of the Simulation System including the physical properties subsystems and involving pseudocomponents and solids stream flows. The hydrotreating reactor model was modified to include improved temperature profile predictions. The plant capital cost estimation subsystem was redesigned to allow use as a stand alone package. The revised package includes a redesigned cost data bank, equipment costing programs, factored plant and auxiliary equipment programs as well as a profitability analysis routine. The physical properties package was updated by the addition of routines for the accurate estimation of the thermodynamic properties of steam. A steady state model of the methanation section were assembled. Scrubber, multi-phase separator, and turbine models were developed for the vapor recovery and heat recovery process sections. DOE

N79-24188# Oak Ridge National Lab., Tenn.
LOW Btu COAL GASIFICATION PROCESSES.
VOLUME 1: SUMMARY, SCREENING, AND COMPARISONS

H. F. Hartman, J. P. Belk, and D. E. Reagan Nov. 1978 140 p refs

(Contract W-7405-eng-26)

(ORNL/ENG/TM-13-Vol-1) Avail: NTIS HC A07/MF A01

A survey was made of 102 reported processes that produce low and intermediate Btu gas from coal. Concise summaries were provided for 47 processes and include status, operating conditions, and a description of the gasifier. Characteristics of different types of gasification processes were compared, and specific comparisons were made for the processes that were investigated in depth. Other process considerations such as potential applications, problem areas, economics, and environmental considerations are discussed. DOE

N79-24189# Department of Energy, Bartlesville, Okla. Energy Technology Center.

MOTOR GASOLINES, SUMMER 1978

Ella Mae Shelton Feb. 1979 79 p refs

(BETC/PPS-79/1) Avail: NTIS HC A05/MF A01

Analytical data for 2,433 samples of motor gasoline, from service stations throughout the country, were collected and analyzed. The samples represent the products of 50 companies, large and small, which manufacture and supply gasoline. These data are tabulated by groups according to brands (unlabeled) and grades for 17 marketing areas and districts into which the country is divided. A map shows marketing areas, districts and sampling locations. Charts indicating the trends of selected properties of motor fuels since 1946 are included. Twelve octane distribution percent charts for areas 1, 2, 3, and 4 for unleaded, regular, and premium grades of gasoline are presented. The antiknock (octane) index $((R + M)/2)$ averages of gasolines sold in this country were 88.5, 89.5 and 94.3 for unleaded, regular, and premium grades of gasolines, respectively. DOE

N79-24190# Mobil Research and Development Corp., Paulsboro, N. J.

FLUID BED PROCESS STUDIES ON SELECTIVE CONVERSION OF METHANOL TO HIGH OCTANE GASOLINE
Final Report

A. Y. Kam Apr. 1978 264 p refs

(Contract EX-76-C-01-2490)

(FE-2490-15) Avail: NTIS HC A12/MF A01

The Mobil fluid bed methanol-to-gasoline process was successfully scaled-up to a 4 barrel-a-day pilot plant. Gasoline selectivity is higher than 88 wt% of hydrocarbons produced, and the octane rating is 96. Gasoline quality is excellent and exceeds all the requirements of unleaded regular gasoline. With this demonstration accomplished, the process is now ready for scale-up to a 100 B/D pilot plant, the final step before constructing commercial size facilities. Methanol was completely converted at design conditions. Steady state operations were demonstrated, and gasoline yield and quality were optimized. Process variable studies showed that duren yields increased with pressure and decreased with temperature. Several process concepts including

light gas recycle, co-feeding liquid/vapor methanol, and heat removal from the fluid bed were evaluated. A process design basis for a large unit was developed. DOE

N79-24191# Environmental Protection Agency, Ann Arbor, Mich. Technology Assessment and Evaluation Branch.

EXHAUST EMISSIONS AND FUEL ECONOMY FROM AUTOMOBILES USING ALCOHOL/GASOLINE BLENDS UNDER HIGH-ALTITUDE CONDITIONS

David Richardson Oct. 1978 28 p

(PB-290612/1; TAEB-79-1) Avail: NTIS HC A03/MF A01 CSCL 21D

Results of emissions tests on ten passenger cars operated on fuel blends containing methanol and ethanol are described. The purpose of the program was to determine the immediate exhaust emission and fuel economy changes due to use of alcohol/gasoline blends under high altitude conditions. The vehicles represented the 1973-1978 model years and were randomly selected from private owners in the Denver area. The test procedures used were the federal test procedure (exhaust emissions only) and the highway fuel economy test. Fuel economy was measured and recorded using the carbon balance technique. GRA

N79-24192# General Accounting Office, Washington, D. C. Energy and Minerals Div.

US REFINING CAPACITY: HOW MUCH IS ENOUGH Report to the Congress

15 Jan. 1979 62 p refs

(PB-291437/2; EMD-78-77) Avail: NTIS HC A04/MF A01 CSCL 21D

From 83 to 92 percent of the Nation's petroleum products were provided from U.S.-based refineries. Between now and 1985, the U.S. refining industry is planning capacity additions which should maintain this position. Whether or not refinery additions should take place will involve domestic and international tradeoffs. This report discusses petroleum product demand, industry expansion plans, and Federal policies affecting those plans. GRA

N79-24259*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PROCEEDINGS OF THE DISTRIBUTION AUTOMATION AND CONTROL WORKING GROUP. VOLUME 1: EXECUTIVE SUMMARY

R. Caldwell Mar. 1979 33 p refs Proc. held at Baltimore, Md., 20-22 Nov. 1978 Prepared for NASA and DOE

(Contract NAS7-100)

(NASA-CR-158642; JPL-PUB-79-35-Vol-1) Avail: NTIS HC A03/MF A01 CSCL 09C

The meeting was sponsored by the Department of Energy, Division of Electric Energy Systems. Its purpose was to bring together some members of the electric utility community so that they might reach a common understanding on: (1) key issues and uncertainties to be resolved, (2) the existing state of the art, and (3) specific requirements for further RD&D in the area of DAC. The statements and recommendations formulated by the group on various topics are presented. J.A.M.

N79-24292 West Virginia Univ., Morgantown.

HEAT TRANSFER SIMULATION IN UNDERGROUND COAL LIQUEFACTION Ph.D. Thesis

Fred Ku Fong 1978 140 p

Avail: Univ. Microfilms Order No. 7910896

The heat transfer problem of a solvent flowing in a cylindrical channel embedded in a medium with a moving boundary is described. Three nonlinear conjugated differential equations describe the process. Numerical methods were devised to solve these three differential equations simultaneously. The numerical methods consist of a combination of two stable methods, namely the ADI iteration method for the parabolic equation and the alternating variable method for the hyperbolic equations. These two methods give very fast convergence and are well suited to nonlinear equations. It was concluded that: the heat loss from the solvent through the coal seam via thermal conduction is negligible and the boundary velocity and thermal conductivity of coal have strong influence on the boundary temperature. Dissert. Abstr.

N79-24293 Drexel Univ., Philadelphia, Pa.
MODELING AND VERIFICATION OF HEAT PUMP PERFORMANCE FOR INDUSTRIAL ENERGY CONSERVATION Ph.D. Thesis

Ramachandran Narayanan 1979 219 p
 Avail: Univ. Microfilms Order No. 7909905

A detailed mathematical simulation of a water-to-water industrial heat pump was developed. A 2kw heat pump employing refrigerant -12 which was locally designed and built was operated in the laboratory. Performance data from the experiment was used to verify the heat pump component and system mathematical models. The four major components of the heat pump cycle, viz., evaporator, condenser, compressor and expansion valve were modeled individually and were coupled together with a system pressure and flow balance. The horizontal evaporator and condenser with tube side water coolant were modeled, employing the NTU-effectiveness techniques with published heat transfer coefficients including change of phase. The reciprocating compressor was modeled as a thermodynamic process incorporating the effects of clearance, cylinder intake and discharge processes and motor efficiency. Dissert. Abstr.

N79-24298* Grumman Aerospace Corp., Bethpage, N.Y.
DESIGN, FABRICATION AND TEST OF A HYDROGEN HEAT PIPE Final Report

J. Alario Feb. 1979 76 p refs
 (Contract NAS2-9291)
 (NASA-CR-152267) Avail: NTIS HC A05/MF A01 CSCL 20D

Re-entrant groove technology was extended to hydrogen heat pipes. Parametric analyses are presented which optimize the theoretical design while considering the limitations of state-of-the-art extrusion technology. The 6063-T6 aluminum extrusion is 14.6 mm OD with a wall thickness of 1.66 mm and contains 20 axial grooves which surround a central 9.3 mm diameter vapor core. Each axial groove is 0.775 mm diameter with a 0.33 mm opening. An excess vapor reservoir is provided at the evaporator to minimize the pressure containment hazard during ambient storage. Modifications to the basic re-entrant groove profile resulted in improved overall performance. While the maximum heat transport capacity decreased slightly to 103 w-m the static wicking height increased markedly to 4.5 cm. The heat pipe became operational between 20 and 30 K after a cooldown from 77 K without any difficulty. Steady state performance data taken over a 19 to 23 K temperature range indicated: (1) maximum heat transport capacity of 5.4 w-m; (2) static wicking height of 1.42 cm; and (3) overall heat pipe conductance of 1.7 watts/deg C. A.R.H.

N79-24306* Battelle Columbus Labs., Ohio.
STUDY OF HEAT TRANSFER THROUGH REFRACTORY LINED GASIFIER VESSEL WALLS Quarterly Progress Report, Apr. - Jun. 1978

J. Richard Schorr Jun. 1978 53 p
 (Contract EX-76-C-01-2210)
 (FE-2210-29) Avail: NTIS HC A04/MF A01

An available furnace was used to conduct tests at atmospheric pressure. A second furnace was built to conduct high pressure tests. The apparatus determines the effects of gas atmosphere, anchor position, and pressure level on heat transfer and temperature profiles in the refractories that are being measured. Checkout work was completed on the high-pressure test apparatus (HPTA), including the pressure control and safety system; the high-pressure test specimen was fabricated; and a procedure for conducting the high-pressure test was formulated. Several modifications to the HPTA and pressure control and safety systems was implemented in order to provide more reliable and safe operation of the systems during the heat transfer measurement tests. DOE

N79-24307* Brookhaven National Lab., Upton, N. Y.
COST-EFFECTIVE POTENTIAL OF OPTIMUMLY DESIGNED HEAT PUMPS FOR THE COLLECTION, STORAGE, AND DISTRIBUTION OF SOLAR ENERGY
 J. G. Cottingham Nov. 1978 10 p refs Presented at ASHRAE

Symp. on Air Infiltration, Philadelphia, 28 Jan. - 1 Feb. 1979
 Submitted for publication
 (Contract EY-76-C-02-0016)

(BNL-25195; Conf-790112-3) Avail: NTIS HC A02/MF A01
 Various solar heat pump configurations are reviewed and the assisted or series configuration identified as the concept having the greatest potential for economic acceptance. The system impact that would result from the development of vapor compression equipment specially tuned to the collection and distribution of solar energy is examined. Major impacts on the solar collector and energy storage elements are identified and reviewed. Solar collectors of crude and inexpensive design, including some passive-like structures, are found to be acceptable in performance and highly desirable economically. Also uninsulated in-the-ground storage found to be beneficial gaining energy from the ground in winter and dissipating it in summer. DOE

N79-24358* National Highway Traffic Safety Administration, Washington, D. C. Technology Assessment Div.

AUTOMOTIVE FUEL ECONOMY CONTRACTOR'S COORDINATION MEETING
 1978 427 p refs Meeting held in Washington, D. C., 11-13 Dec. 1978

(PB-290516/4; DOT-HS-803-706) Avail: NTIS HC A19/MF A01 CSCL 10A

This document is intended to be an effective and timely means of broadly disseminating a full and up-to-date review of the automotive fuel economy research and analysis program objectives and progress. Topic areas covered include: Fuel economy and emissions considerations; Motor vehicle demand forecasting; Consumer research; Engines; Weight reduction; and Industrial behavior. GRA

N79-24408 Pennsylvania State Univ., University Park.
EVALUATION OF FLOW PROPERTIES OF DILUTE AQUEOUS POLYMER SOLUTIONS FOR ENHANCED OIL RECOVERY APPLICATIONS Ph.D. Thesis

Esref Uansal 1978 362 p
 Avail: Univ. Microfilms Order No. 7909143

The properties of the solutions of xanthan gum, sodium cellulose sulfate esters, polyacrylamides, and hydroxy ethyl cellulose and the injectabilities of these solutions into porous media were investigated. Xanthan gum solutions require orifice mixing and filtration in order to have good flow properties through porous media. The solution properties of sodium cellulose sulfate esters were similar to those of xanthan gum. The solution properties of Polyacrylamides were extremely sensitive to the system variables. Because of the intermolecular associations, these polymers could not be filtered effectively or injected into fine porous media. Solutions of hydroxy ethyl compounds were insensitive to system variables. They could not be injected into fine porous media because of the high concentrations required for mobility control purposes. Dissert. Abstr.

N79-24417* Shaker Research Corp., Ballston Lake, N. Y.
DEVELOPMENT OF SENSITIZED PICK COAL INTERFACE DETECTOR SYSTEM Final Report

R. F. Burchill 1979 67 p
 (Contract NAS8-32538)
 (NASA-CR-161225) Avail: NTIS HC A04/MF A01 CSCL 08I

One approach for detection of the coal interface is measurement of the pick cutting heads and shock through the use of pick strain gage load cells and accelerometers. The cutting drum of a long wall mining machine contains a number of cutting picks. In order to measure pick loads and shocks, one pick was instrumented and telemetry used to transmit the signals from the drum to an instrument-type tape recorder. A data system using FM telemetry was designed to transfer cutting bit load and shock information from the drum of a longwall shearer coal mining machine to a chassis mounted data recorder. G.Y.

N79-24423* City of Desert Hot Springs, Calif.
SELF-STARTING MANUAL FOR DIRECT USE APPLICATIONS OF GEOTHERMAL RESOURCES Final Report
 Chris C. Christiansen Jul. 1978 129 p refs Sponsored in

part by California Energy Commission
(Contract EY-77-C-03-1329)

(PB-290872/1; CAEC-25; SAN-1329-5) Avail: NTIS
HC A07/MF A01 CSCL 08I

Communities located near geothermal resources and interested in nonelectric uses of this energy can refer to the Self-Start Manual for aid when evaluating and beginning possible programs. Knowledge gained from programs begun in Desert Hot Springs, California, is presented, including the problems and options associated with exploration of the geothermal area, environmental reports, permits, siting and technology. The steps necessary to achieve full use of geothermal resources, from measuring the extent of the geothermal area to screening project applications, are discussed. Financing options were investigated. GRA

N79-24432* National Aeronautics and Space Administration. Pasadena Office, Calif.

PRIMARY REFLECTOR FOR SOLAR ENERGY COLLECTION SYSTEMS AND METHOD OF MAKING SAME Patent

Charles G. Miller (JPL) and James B. Stephens, inventors (to NASA) (JPL) Issued 17 Apr. 1979 9 p Filed 25 Jan. 1977 Supersedes N77-20566 (15 - 11, p 1473) Division of US Patent Appl-SN-598969, filed 24 Jul. 1975, US Patent-4,065,053 Sponsored by NASA

(NASA-Case-NPO-13579-3; US-Patent-4,149,817;
US-Patent-Appl-SN-762363; US-Patent-Class-405-229;
US-Patent-Class-126-270; US-Patent-Class-264-1;
US-Patent-Class-264-33; US-Patent-Class-264-34;
US-Patent-Class-264-35; US-Patent-Class-264-70;
US-Patent-Class-264-71; US-Patent-Class-264-510;
US-Patent-Class-264-516; US-Patent-Class-350-292;
US-Patent-Class-350-294; US-Patent-Class-350-296;
US-Patent-Class-405-263; US-Patent-4,065,053;
US-Patent-Appl-SN-598969) Avail: US Patent and Trademark Office CSCL 10A

Solar energy is reflected to a movably supported collector that is kept at the concentrated line focus of the reflector primary by a fixed, linear, ground-based primary reflector having an extended curved sawtooth contoured surface covered with a metalized polymeric reflecting material. The primary reflector was constructed by a process utilizing well-known freeway paving machinery.

Official Gazette of the U.S. Patent and Trademark Office

N79-24433* National Aeronautics and Space Administration. Pasadena Office, Calif.

SOLAR ENERGY COLLECTION SYSTEM Patent

Charles G. Miller (JPL) and James B. Stephens, inventors (to NASA) (JPL) Issued 17 Apr. 1979 27 p Filed 25 Jan. 1977 Supersedes N77-20565 (15 - 11, p 1473) Division of US Patent Appl. SN-598969, filed 24 Jul. 1975, US Patent-4,065,053 Sponsored by NASA

(NASA-Case-NPO-13579-2; US-Patent-4,149,521;
US-Patent-Appl-SN-762362; US-Patent-Class-126-271;
US-Patent-Class-237-1A; US-Patent-Class-350-288;
US-Patent-Class-350-299; US-Patent-Class-126-400;
US-Patent-4,065,053; US-Patent-Appl-SN-598969) Avail: US Patent and Trademark Office CSCL 10A

A fixed, linear, ground-based primary reflector having an extended curved sawtooth-contoured surface covered with a metalized polymeric reflecting material, reflects solar energy to a movably supported collector that is kept at the concentrated line focus reflector primary. The primary reflector may be constructed by a process utilizing well known freeway paving machinery. The solar energy absorber is preferably a fluid transporting pipe. Efficient utilization leading to high temperatures from the reflected solar energy is obtained by cylindrical shaped secondary reflectors that direct off-angle energy to the absorber pipe. A seriatim arrangement of cylindrical secondary reflector stages and spot-forming reflector stages produces a high temperature solar energy collection system of greater efficiency.

Official Gazette of the U.S. Patent and Trademark Office

N79-24434 Kansas Univ., Lawrence.

COMPARISON OF THREE EXPERIMENTAL METHODS USED IN DETERMINING THE THERMAL PERFORMANCE

OF FLAT-PLATE SOLAR COLLECTORS Ph.D. Thesis

Gregory Barton Hotchkiss 1978 291 p

Avail: Univ. Microfilms Order No. 7910636

Three experimental methods for evaluating the thermal performance of flat-plate solar collectors are presented. The methods are classified according to the nature of the ambient conditions encountered during experimental testing. The classifications are: (1) steady state, (2) quasi-steady state, and (3) unsteady state. Experimental tests on two solar collectors were conducted in an indoor solar simulator and also out-of-doors. From the experimental collector data, collector efficiency factors, which describe the steady state behavior of a collector, were determined for each experimental method. A parameter identification method based upon a discrete gradient optimization technique was used to determine the collector parameters from unsteady state data. The design, construction, and operation of the test rig which was used to obtain the experimental data is also described.

Dissert. Abstr.

N79-24435*# National Aeronautics and Space Administration, Washington, D. C.

PRELIMINARY ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS). VOLUME 1: EXECUTIVE SUMMARY

Oct. 1978 49 p refs Prepared in cooperation with DOE, Washington, D. C. 2 Vol.

(NASA-TM-80354; DOE/ER-0021/1) Avail: NTIS
HC A03/MF A01 CSCL 10B

Volume 1 of a two volume report is presented. Volume 2 provides a abstract of the more technically explicit information contained in Volume 2 concerning the preliminary assessment of the impact of the Satellite Power System (SPS) on the environment for the edification of the interested layman. Topics discussed in this volume include: (1) microwave health and ecological effects; (2) other effects on health and the environment; (3) effects on the atmosphere; and (4) effects on communication.

G.Y.

N79-24436*# National Aeronautics and Space Administration, Washington, D. C.

PRELIMINARY ENVIRONMENTAL ASSESSMENT FOR THE SATELLITE POWER SYSTEM (SPS). VOLUME 2: DETAILED ASSESSMENT

Oct. 1978 175 p refs Prepared in cooperation with DOE, Washington, D. C. 2 Vol.

(NASA-TM-80355; DOE/ER-0021/2) Avail: NTIS
HC A08/MF A01 CSCL 10B

Volume 2 provides a preliminary assessment of the impact of the Satellite Power System (SPS) on the environment in a technically detailed format more suitable for peer review than the executive summary of Vol. 1. It serves to integrate and assimilate information that has appeared in documents referenced herein and to focus on issues that are purely environmental. It discloses the state-of-knowledge as perceived from recently completed DOE-sponsored studies and defines prospective research and study programs that can advance the state-of-knowledge and provide an expanded data base for use in an assessment planned for 1980. Alternatives for research that may be implemented in order to achieve this advancement are also discussed.

Author

N79-24437*# AiResearch Mfg. Co., Torrance, Calif.

PROTOTYPE SOLAR HEATING AND COOLING SYSTEMS Monthly Progress Report, 1 Nov. 1978 - 28 Feb. 1979

Apr. 1979 48 p Prepared for DOE

(Contract NAS8-32091)

(NASA-CR-161204) Avail: NTIS HC A03/MF A01 CSCL 10A

A combination of monthly progress reports are presented. It contains a summary of activities and progress made from November 1, 1978, to February 28, 1979. The effort calls for the development, manufacture, test, system installation, maintenance, problem resolution, and performance evaluation. G.Y.

N79-24439* National Aeronautics and Space Administration, Washington, D. C.

SOLAR TECHNOLOGY IN THE FEDERAL REPUBLIC OF GERMANY

May 1979 75 p Transl. into ENGLISH of "Solartechnik in der Bundesrepublik Deutschland", Rept. Bundesverband Solarenergie, Athens, 10 Nov. 1978 p 1-38 Transl. by Kanner (Leo) Associates, Redwood City, Calif.

(Contract NASw-3199)

(NASA-TM-75634) Avail: NTIS HC A04/MF A01 CSCL 10A

A series of papers dealing with the status of solar research and development in the Federal Republic of Germany are presented at a conference in Greece with the object of promoting international cooperation in solar energy utilization. The reports focus on solar collector designs, solar systems, heat pumps, solar homes, solar cooling and refrigeration, desalination and electric power generation. Numerous examples of systems produced by German manufacturers are illustrated and described, and performance data are presented. Author

N79-24442* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

REDOX FLOW CELL ENERGY STORAGE SYSTEMS

Lawrence H. Thaller 1979 11 p refs

(Contract E(49-28)-1002)

(NASA-TM-79143; DOE/NASA/1002-79/3; E-9996) Avail: NTIS HC A02/MF A01 CSCL 10A

NASA-Redox systems are electrochemical storage devices that use two fully soluble Redox couples, anode and cathode fluids, as active electrode materials separated by a highly selective ion exchange membrane. The reactants are contained in large storage tanks and pumped through a stack of Redox flow cells where the electrochemical reactions (reduction and oxidation) take place at porous carbon felt electrodes. A string or stack of these power producing cells is connected in series in a bipolar manner. Redox energy storage systems promise to be inexpensive and possess many features that provide for flexible design, long life, high reliability and minimal operation and maintenance costs. These features include independent sizing of power and storage capacity requirements and inclusion within the cell stack of a cell that monitors the state of charge of the system as a whole, and a rebalance cell which permits continuous correction to be made for minor side reactions that would tend to result in the anode fluid and cathode fluids becoming electrochemically out of balance. These system features are described and discussed. L.S.

N79-24443* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

DESCRIPTION OF PHOTOVOLTAIC VILLAGE POWER SYSTEMS IN THE UNITED STATES AND AFRICA

A. F. Ratajczak and W. J. Bifano 1979 13 p refs Presented at the Photovoltaic Solar Energy Conf., Berlin, 23-26 Apr. 1979 (Contract DE-A101-79ET20485)

(NASA-TM-79149; DOE/NASA/20485-79/1; E-005) Avail: NTIS HC A02/MF A01 CSCL 10B

Photovoltaic power systems in remote villages in the United States and Africa are described. These projects were undertaken to demonstrate that existing photovoltaic system technology is capable of providing electrical power for basic domestic services for the millions of small, remote communities in both developed and developing countries. One system is located in the Papago Indian Village of Schuchuli in southwest Arizona (U. S.) and became operational 16 December 1978. The other system is located in Tangaye, a rural village in Upper Volta, Africa. It became operational 1 March 1979. The Schuchuli system has a 3.5 kW (peak) solar array which provides electric power for village water pumping, a refrigerator for each family, lights in the village buildings, and a community washing machine and sewing machine. The 1.8 kW (peak) Tangaye system provides power for community water pumping, flour milling and lights in the milling building. These are both stand-alone systems (i.e., no back-up power source) which are being operated and maintained by local personnel. Both systems are instrumented. Systems operations are being monitored by NASA to measure design adequacy and to refine designs for future systems. J.M.S.

N79-24444* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

BENEFITS OF ADVANCED TECHNOLOGY IN INDUSTRIAL COGENERATION

G. J. Barna and R. K. Burns 1979 29 p Presented at EPRI Workshop on Cogeneration, San Antonio, Tex., 1-4 Apr. 1979 (Contract EC-77-A-31-1062)

(NASA-TM-79160; DOE/NASA/1062-79/1; E-016) Avail: NTIS HC A03/MF A01 CSCL 10B

This broad study is aimed at identifying the most attractive advanced energy conversion systems for industrial cogeneration for the 1985 to 2000 time period and assessing the advantages of advanced technology systems compared to using today's commercially available technology. Energy conversion systems being studied include those using steam turbines, open cycle gas turbines, combined cycles, diesel engines, Stirling engines, closed cycle gas turbines, phosphoric acid and molten carbonate fuel cells and thermionics. Specific cases using today's commercially available technology are being included to serve as a baseline for assessing the advantages of advanced technology. L.S.

N79-24445* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

REDOX FLOW CELL DEVELOPMENT AND DEMONSTRATION PROJECT, CALENDAR YEAR 1977

Jan. 1979 53 p refs

(Contract E(49-28)-1002)

(NASA-TM-79067; DOE/NASA/1002-78/2; E-9883) Avail: NTIS HC A04/MF A01 CSCL 10A

Research and development on the redox flow cell conducted from January 1, 1977, to December 31, 1977, are described in this report. The major focus of the effort during 1977 was the key technology issues that directly influence the fundamental feasibility of the overall redox concept. These issues were the development of a suitable ion exchange membrane for the system, the screening and study of candidate redox couples to achieve optimum cell performance, and the carrying out of systems analysis and modeling to develop system performance goals and cost estimates. L.S.

N79-24446* National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

PERFORMANCE OPTIMIZATION OF AN MHD GENERATOR WITH PHYSICAL CONSTRAINTS

C. C. P. Pian, G. R. Seikel, and J. Marlin Smith 1979 12 p refs Proposed for presentation at 14th Intersoc. Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979

(Contract EF-77-A-01-2674)

(NASA-TM-79172; DOE/NASA/2674-79/5; E-036) Avail: NTIS HC A02/MF A01 CSCL 10B

A method to optimize the Faraday MHD generator performance under a prescribed set of electrical and magnet constraints is described. The results of generator performance calculations using this technique are presented for a very large MHD/steam plant. The differences between the maximum power and maximum net power generators are described. The sensitivity of the generator performance to the various operational parameters are presented. Author

N79-24448* AeroChem Research Labs., Inc., Princeton, N. J. **DEVELOPMENT OF A MODEL AND COMPUTER CODE TO DESCRIBE SOLAR GRADE SILICON PRODUCTION PROCESSES**

R. Srivastava and R. K. Gould May 1979 33 p refs Prepared for DOE

(Contract JPL-954862)

(NASA-CR-158679; AeroChem-TN-206;

DOE/JPL-954862-79/6; QR-6)

Avail: NTIS HC A03/MF A01 CSCL 10A

Mathematical models and computer codes based on these models, which allow prediction of the product distribution in chemical reactors for converting gaseous silicon compounds to condensed-phase silicon were developed. The following tasks were

accomplished: (1) formulation of a model for silicon vapor separation/collection from the developing turbulent flow stream within reactors of the Westinghouse (2) modification of an available general parabolic code to achieve solutions to the governing partial differential equations (boundary layer type) which describe migration of the vapor to the reactor walls, (3) a parametric study using the boundary layer code to optimize the accomplished: (1) formulation of a model for silicon vapor separation/collection from the developing turbulent flow stream within reactors of the Westinghouse (2) modification of an available general parabolic code to achieve solutions to the governing partial differential equations (boundary layer type) which describe migration of the vapor to the reactor walls, (3) a parametric study using the boundary layer code to optimize the performance characteristics of the Westinghouse reactor, (4) calculations relating to the collection efficiency of the new AeroChem reactor, and (5) final testing of the modified LAPP code for use as a method of predicting Si(1) droplet sizes in these reactors. S.E.S.

N79-24454* Optical Coating Lab., Inc., City of Industry, Calif. Photoelectronics Div.

DEVELOPMENT OF HIGH EFFICIENCY (14%) SOLAR CELL ARRAY MODULE Quarterly Report, 29 Nov. 1978 - 15 Mar. 1979

P. A. Iles, S. Khemthong, S. Olah, W. J. Sampson, and K. S. Ling 15 Mar. 1979 30 p refs Prepared for JPL and DOE (Contract JPL-955217)

(NASA-CR-158672; QR-1; DOE/JPL-955217-79/4) Avail: NTIS HC A03/MF A01 CSCL 10A

High efficiency solar cells required for the low cost modules was developed. The production tooling for the manufacture of the cells and modules was designed. The tooling consisted of: (1) back contact soldering machine; (2) vacuum pickup; (3) antireflective coating tooling; and (4) test fixture. S.E.S.

N79-24455* ARCO Solar, Inc., Chatsworth, Calif.

AUTOMATED SOLAR PANEL ASSEMBLY LINE. LSA TASK: PRODUCTION PROCESSES AND EQUIPMENT

H. Somberg 8 Apr. 1979 18 p Prepared for JPL and DOE (Contract JPL-955278)

(NASA-CR-158671; DOE/JPL-955278-79/1; QR-1) Avail: NTIS HC A02/MF A01 CSCL 10A

An automated solar panel production line which reduces the module assembly costs was designed. The module design, solar cell assembly prototype, and solar panel lamination prototype are discussed. S.E.S.

N79-24456* Solarex Corp., Rockville, Md.

ANALYSIS OF THE EFFECTS OF IMPURITIES IN SILICON Quarterly Report, 19 Jan. - 30 Apr. 1979

J. H. Wohlgemuth 30 Apr. 1979 36 p refs Prepared for JPL

(Contract JPL-955307)

(NASA-CR-157439; DOE/JPL-955307-79/1; QR-1) Avail: NTIS HC A03/MF A01 CSCL 10A

A solar cell fabrication and analysis program was conducted to determine the effects on the resultant solar cell efficiency of impurities intentionally incorporated into silicon. The program employed flight quality technologies and quality assurance to assure that variations in cell performance were due to the impurities incorporated in the silicon. The initial verification runs have resulted in an average AMO cell efficiency of 12.8% at 25 C. R.E.S.

N79-24457* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. **LOW-COST SOLAR ARRAY (LSA) PROJECT Quarterly Report, Jan. - Mar. 1978**

Mar. 1978 72 p Prepared for DOE

(Contract NAS7-100)

(NASA-CR-158650; JPL-Pub-79-14; DOE/JPL-1012-2; QR-8) Avail: NTIS HC A04/MF A01 CSCL 10A

Progress made by the Low-Cost Silicon Solar Array Project during the period January through March 1978 is reported. It includes task reports on silicon material processing, large-area silicon sheet development, encapsulation materials testing and development, project engineering and operations, and manufacturing techniques, plus the steps taken to integrate these efforts. G.Y.

N79-24458* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. **LOW-COST SOLAR ARRAY (LSA) PROJECT Quarterly Report, Apr. - Jun. 1978**

Jun. 1978 60 p Prepared for DOE

(Contract NAS7-100)

(NASA-CR-158651; JPL-Pub-79-15; DOE/JPL-1012-3; QR-9) Avail: NTIS HC A04/MF A01 CSCL 10A

The activities of the Low-Cost Solar Array Project are described for the period April through June 1978. The Project is assigned responsibility for advancing solar array technology while encouraging industry to reduce the price of arrays to a level at which photovoltaic electric power systems will be competitive with more conventional power sources early in the next decade. Set forth are the goals and plans with which the Project intends to accomplish this and the progress that was made during the quarter. G.Y.

N79-24459* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

LSA: LOW-COST SOLAR ARRAY PROJECT Quarterly Report, Jul. 1978 - Sep. 1978

Sep. 1978 61 p

(Contract NAS7-100; JPL Proj. 5101-100)

(NASA-CR-158533; JPL-Pub-79-43-Vol-1; JPL-1012-4) Avail: NTIS HC A04/MF A01 CSCL 10A

Topics discussed include silicon material processing; large-area silicon sheet development; encapsulation materials testing and development; project engineering and operations activities, and manufacturing techniques. The steps taken to integrate these efforts, are described. A.R.H.

N79-24460* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

THERMAL STORAGE APPLICATIONS WORKSHOP. VOLUME 1: PLENARY SESSION ANALYSIS

15 Feb. 1979 21 p Workshop held at Golden, Colo., 14-15 Feb. 1978 Prepared for NASA and DOE 2 Vol.

(Contract NAS7-100; JPL Proj. 5102-78)

(NASA-CR-158643; JPL-Pub-79-8-Vol-1; DOE/JPL-1060-12-Vol-1) Avail: NTIS HC A02/MF A01 CSCL 10C

The importance of the development of inexpensive and efficient thermal and thermochemical energy storage technology to the solar power program is discussed in a summary of workshop discussions held to exchange information and plan for future systems. Topics covered include storage in central power applications such as the 10 MW-e demonstration pilot receiver to be constructed in Barstow, California; storage for small dispersed systems, and problems associated with the development of storage systems for solar power plants interfacing with utility systems. A.R.H.

N79-24461* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

THERMAL STORAGE APPLICATIONS WORKSHOP. VOLUME 2: CONTRIBUTED PAPERS

15 Feb. 1979 282 p refs Workshop held at Golden, Colo., 14-15 Feb. 1978 Prepared for NASA and DOE 2 Vol.

(Contract NAS7-100; JPL Proj. 5102-78)

(NASA-CR-158644; JPL-Pub-79-8-Vol-2; DOE/JPL-1060-12-Vol-2) Avail: NTIS HC A13/MF A01 CSCL 10C

The solar thermal and the thermal and thermochemical energy storage programs are described as well as the technology requirements for both external (electrical) and internal (thermal, chemical) modes for energy storage in solar power plants. Specific technical issues addressed include thermal storage criteria for solar power plants interfacing with utility systems; optimal dispatch of storage for solar plants in a conventional electric grid; thermal storage/temperature tradeoffs for solar total energy systems; the value of energy storage for direct-replacement solar thermal power plants; systems analysis of storage in specific solar thermal power applications; the value of seasonal storage of solar energy; criteria for selection of the thermal storage system for a 10 MW(2) solar power plant; and the need for specific requirements by storage system development teams. A.R.H.

N79-24462*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**THERMAL POWER SYSTEMS, SMALL POWER SYSTEMS
 APPLICATION PROJECT. VOLUME 1: EXECUTIVE
 SUMMARY Annual Technical Report, FY 1978**

A. T. Marriott 15 Jan. 1979 76 p Prepared for DOE
 (Contract NAS7-100; JPL Proj. 5103-36)
 (NASA-CR-157441; JPL-Pub-79-43-Vol-1; DOE/JPL-1060-9)
 Avail: NTIS HC A05/MF A01 CSCL 10B

Current small power system technology as applied to power plants up to 10 MWe in size was assessed. Markets for small power systems were characterized and cost goals were established. Candidate power plant system design concepts were selected for evaluation and preliminary performance and cost assessments were made. Economic studies were conducted and breakeven capital costs were determined for leading contenders among the candidate systems. An application study was made of the potential use of small power systems in providing part of the demand for pumping power by the extensive aqueduct system of California, estimated to be 1000 MWe by 1985. Criteria and methodologies were developed for application to the ranking of candidate power plant system design concepts. Experimental power plants concepts of 1 MWe rating were studied leading toward the definition of a power plant configuration for subsequent detail design, construction, testing and evaluation as Engineering Experiment No. 1 (EE No. 1). Site selection criteria and ground rules for the solicitation of EE No. 1 site participation proposals by DOE were developed. A.R.H.

N79-24463*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**HIGH-EFFICIENCY THIN-FILM GaAs SOLAR CELLS
 Final Report**

R. J. Stirn 15 Apr. 1979 99 p refs Prepared for NASA and DOE
 (Contract NAS7-100)
 (NASA-CR-158641; JPL-Pub-79-38) Avail: NTIS
 HC A05/MF A01 CSCL 10A

GaAs chemical vapor deposition (CVD) growth on single-crystal GaAs substrates was investigated over a temperature range of 600 to 750 C. As/GA mole-ratio range of 3 to 11, and gas molefraction range 5×10^{-4} to the minus 9th power to 7×10^{-4} to the minus 7th power for H₂S doping. GasAs CVD growth on recrystallized Ge films was investigated for a temperature range of 550 to 700 C, an As/GA mole ratio of 5, and for various H₂S mole fraction. The highest efficiency cell observed on these films with 2 mm dots was 4.8% (8% when AR-coated). Improvements in fill factor and opencircuit voltage by about 40% each are required in order to obtain efficiencies of 15% or greater. M.M.M.

N79-24464*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**THERMAL POWER SYSTEMS, POINT-FOCUSING DIS-
 TRIBUTED RECEIVER TECHNOLOGY PROJECT.
 VOLUME 2: DETAILED REPORT Annual Technical Report,
 Fiscal Year 1978**

John Lucas 15 Mar. 1979 124 p refs Prepared for DOE
 (Contract NAS7-100; JPL Proj. 5104-26)
 (NASA-CR-158534; DOE/JPL-1060-7; JPL-Pub-79-1) Avail:
 NTIS HC A06/MF A01 CSCL 10A

Thermal or electrical power from the sun's radiated energy through Point-Focusing Distributed Receiver technology is the goal of this Project. The energy thus produced must be economically competitive with other sources. The Project supports the industrial development of technology and hardware for extracting energy from solar power to achieve the stated goal. Present studies are working to concentrate the solar energy through mirrors or lenses, to a working fluid or gas, and through a power converter change, to an energy source useful to man. Rankine-cycle and Brayton-cycle engines are currently being developed as the most promising energy converters for our near future needs. Author

N79-24465*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**THE PARABOLIC CONCENTRATING COLLECTOR: A
 TUTORIAL**

V. C. Truscello 15 Feb. 1979 47 p refs Prepared for JPL and DOE

(Contracts NAS7-100; EX-76-A-29-1060; JPL Proj. 5102-107)
 (NASA-CR-158639; JPL-Pub-79-7; DOE/JPL-1060-79/1)
 Avail: NTIS HC A03/MF A01 CSCL 10A

A tutorial overview is presented of point-focusing parabolic collectors. Optical and thermal characteristics of such collectors are discussed. Data representing typical achievable collector efficiencies are presented and the importance of balancing collector cost with concentrator quality is argued. The impact of receiver temperature on performance is assessed and the general observation made that temperatures much in excess of 1500-2000 F can actually result in decreased performance. Various types of two-axis tracking collectors are described. The present DOE program to develop these devices is briefly discussed, as are present and projected costs for these collectors. G.Y.

N79-24466*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
**HEAP: HEAT ENERGY ANALYSIS PROGRAM, A COMPUT-
 ER MODEL SIMULATING SOLAR RECEIVERS**

F. L. Lansing 15 Jan. 1979 138 p refs Prepared For NASA and JPL
 (Contract NAS7-100; JPL Proj. 5102-106)
 (NASA-CR-158640; DOE/JPL-1060-13; JPL-PUB-79-13) Avail:
 NTIS HC A07/MF A01 CSCL 10A

A computer program which can distinguish between different receiver designs, and predict transient performance under variable solar flux, or ambient temperatures, etc. has a basic structure that fits a general heat transfer problem, but with specific features that are custom-made for solar receivers. The code is written in MBASIC computer language. The methodology followed in solving the heat transfer problem is explained. A program flow chart, an explanation of input and output tables, and an example of the simulation of a cavity-type solar receiver are included. A.R.H.

N79-24467# Committee on Banking, Housing and Urban Affairs
 (U. S. Senate).

IMPACT OF SOLAR ENERGY ON RURAL HOUSING

Washington GPO 1978 303 p refs Hearings before the Subcomm. on Rural Housing of the Comm. on Banking, Housing, and Urban Affairs, 95th Congr., 2d Sess., 19-20 Jul. 1978 (GPO-31-641) Avail: Subcomm. on Rural Housing

The subject of solar energy and the impact that this technology can have on the life of rural families is discussed through witness testimony from Government and private industry. G.Y.

N79-24468# National Inst. for Water Research, Pretoria (South Africa).

**ENERGY RECOVERY FROM DOMESTIC REFUSE BY MEANS
 OF INCINERATION AND PYROLYSIS**

J. H. Nell 1978 34 p refs
 (CSIR-SR-WAT-54; ISBN-0-7988-1399-7) Avail: NTIS
 HC A03/MF A01

The present status of energy recovery from domestic refuse by means of incineration and pyrolysis is reviewed. Technological and cost aspects are discussed, while examples of plants presently in operation are given. It is concluded that energy recovery from domestic refuse has certain advantages over conventional disposal methods with respect to land requirements, pollution control, recycling of valuable materials, recovery of energy and costs. However, the disadvantages, especially the high capital expenditure required to comply with strict air pollution regulations, necessitate an observation period of five to eight years in order to assess the applicability of the process for local conditions. Author

N79-24469*# Westinghouse Research and Development Center,
 Pittsburgh, Pa.

**THE ARRAY AUTOMATED ASSEMBLY TASK FOR THE LOW
 COST SOLAR ARRAY PROJECT, PHASE 2 Annual Report,
 1 Oct. 1977 - 30 Oct. 1978**

R. B. Campbell, ed. and S. Farukhi, ed. 16 Nov. 1978 185 p refs Sponsored in part by DOE Prepared for JPL
 (Contracts NAS7-100; JPL-954873)
 (NASA-CR-158538; DOE/JPL-954873-78/01; JPL-9950-28;
 AR-1) Avail: NTIS HC A03/MF A01 CSCL 10A

During the program a process sequence was proposed and tested for the fabrication of dendritic web silicon into solar

modules. This sequence was analyzed as to yield and cost and these data suggest that the price goals of 1986 are attainable. Specifically, it was shown that a low cost POCL3 is a suitable replacement for the semiconductor grade, and that a suitable CVD oxide can be deposited from a silane/air mixture using a Silox reactor. A dip coating method was developed for depositing an antireflection coating from a metalorganic precursor. Application of photoresist to define contact grids was made cost effective through use of a dip coating technique. Electroplating of both Ag and Cu was shown feasible and cost effective for producing the conductive metal grids on the solar cells. Laser scribing was used to separate the cells from the dendrites without degradation. Ultrasonic welding methods were shown to be feasible for interconnecting the cells. A study of suitable low cost materials for encapsulation suggest that soda lime glass and phenolic filled board are preferred. L.S.

N79-24471*# Dow Corning Corp., Midland, Mich.
DEVELOP SILICONE ENCAPSULATION SYSTEMS FOR TERRESTRIAL SILICON SOLAR ARRAYS Interim Report, 15 Feb. - 31 Dec. 1978

Mar. 1979 78 p refs Sponsored by NASA and DOE Prepared for JPL

(Contract JPL-954995)

(NASA-CR-158537; DOE/JPL-954995-78/3; JPL-9950-39) Avail: NTIS HC A05/MF A01 CSCL 10A

The results for Task 3 of the Low Cost Solar Array Project are presented. Task 3 is directed toward the development of a cost effective encapsulating system for photovoltaic modules using silicon based materials. The technical approach of the contract effort is divided into four special tasks: (1) technology review; (2) generation of concepts for screening and processing silicon encapsulation systems; (3) assessment of encapsulation concepts; and (4) evaluation of encapsulation concepts. The candidate silicon materials are reviewed. The silicon and modified silicon resins were chosen on the basis of similarity to materials with known weatherability, cost, initial tangential modulus, accelerated dirt pick-up test results and the ratio of the content of organic phenyl substitution of methyl substitution on the backbone of the silicon resin. G.Y.

N79-24475# Naval Civil Engineering Lab., Port Hueneme, Calif.
DIGEST OF EQUIPMENT FOR CONVERTING SOLAR, WIND, AND GEOTHERMAL ENERGY INTO ELECTRIC POWER FOR USN APPLICATION ASHORE Final Report, May 1977 - Mar. 1978

William R. Lorman Nov. 1978 106 p refs (AD-A066221; CEL-TN-1534) Avail: NTIS HC A06/MF A01 CSCL 10/2

This document enumerates principal requirements of self-sufficient electric power conversional equipment under active consideration by CEL. Data pertain to financial requirements, physical characteristics, and potential outputs of solar, wind, and geothermal energy conversion systems; these systems are part of USN shore energy research and development program. Data are intended for use by CEL systems analysts as input to mathematical model for planning and optimizing power systems throughout the Naval Shore Establishment. Author (GRA)

N79-24476# California Univ., Berkeley. Lawrence Berkeley Lab.

TRANSPARENT HEAT MIRRORS FOR PASSIVE SOLAR HEATING APPLICATIONS

Stephen Selkowitz Mar. 1978 26 p Presented at the 2d Natl. Passive Solar Conf., Philadelphia, 16-18 Mar. 1978 (Contract W-7405-eng-48)

(LB L-7829; Conf-780337-8; FFB-W-78-03) Avail: NTIS HC A03/MF A01

Progress in the development of transparent heat mirror coatings for energy efficient windows and passive solar applications is reviewed. The availability of cost efficient coatings promising savings of 25 to 75 %, depending upon application, to window manufacturers and homeowners is reported. Performance, applications, and limitations are discussed. DOE

N79-24478# Los Alamos Scientific Lab., N: Mex.
TREATMENT OF MOLYBDENITE ORE USING A 2 kW SOLAR FURNACE

S. R. Skaggs 1979 26 p Presented at the Solar Thermal Test Facilities Users Assoc., Atlanta, 27-29 Sep. 1978 Submitted for publication

(Contract W-7405-eng-36)

(LA-UR-79-6; Conf-780956-3) Avail: NTIS HC A03/MF A01

The Odello facility including the 1 MW furnace operated by the Laboratoire of Energetique Solaire, and the 116 and 2 kW furnaces operated by the Laboratoire des Ultra-Refractaires is described. The experiments conducted during August and September 1978 for the solar processing of molybdenite ore are described. Kinetics data on the molybdenite oxidation reaction, a mass balance in order to project to pilot plant size, and calorimetric data on the reaction was obtained. The results of these three measurements are presented graphically. The techniques being considered for pilot plant trials are discussed, and a schedule of the work to be completed is included. DOE

N79-24479# California Univ., Livermore. Lawrence Livermore Lab.

IN SITU COAL GASIFICATION MODELING

C. B. Thorsness and R. J. Cena 2 Feb. 1979 37 p refs Presented at the AICE Meeting, Houston, Tex., 1-4 Apr. 1979 (Contract W-7405-eng-48)

(UCRL-82269; Conf-790405-3) Avail: NTIS HC A03/MF A01

A two dimensional coal recovery model which incorporates several candidate mechanisms believed to control in situ gasification is presented. The model is tested against field gasification results from Hoe Creek and Hanna, Wyoming. Both experiments demonstrated wide sweep efficiency. Analysis of results based on overall material balances indicate possible large differences in the net amount of unreacted char left underground. Mathematical model to predict wide sweep efficiency for both sites require the use of a highly dispersive mechanism within the active gasification region. Tracer studies at Hoe Creek confirm the highly dispersive nature of the system. A quasi-equilibrium model is presented for calculating gas composition as a function of underground heat loss and water influx. Plans for incorporating this model in the two dimensional coal recovery model are presented. DOE

N79-24480# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT COST REPORT: RADIAN CORPORATION OFFICE BUILDING, AUSTIN, TEXAS

2 May 1978 39 p ref

(Contracts W-31-109-eng-38; EG-77-C-01-4049)

(SOLAR/2002-78/60) Avail: NTIS HC A03/MF A01

Cost information is presented for a solar heating and cooling project which utilizes 36 concentrating collectors which provide an effective aperture area of 350 square feet. The collectors are ganged in two banks on the flat roof of the building. An aluminum angle support structure tilts the collectors toward the south and the collectors track the sun from east to west through the day. A tracking mechanism is provided for each of the two banks of collectors. The 1500 gallon insulated, fiberglass storage tank is located above ground on a concrete pad near the building. The construction costs of this solar heating and cooling project are presented. Category costs are listed by materials owner direct labor and subcontract costs. The subcontract costs include both materials, labor, overhead and profit costs for mechanical and electrical subcontractors. DOE

N79-24481# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT DESCRIPTION: SCATTERGOOD SCHOOL RECREATION CENTER, WEST BRANCH, IOWA

26 May 1978 44 p

(Contracts EG-77-C-01-4049; EG-77-C-01-2522)

(SOLAR/2003-78/50) Avail: NTIS HC A03/MF A01

A 4-tier collector array, tilted at 50 deg consists of 128 double glazed collectors that use air as the heat transfer fluid. The array is attached to the southward facing gymnasium wall

on a partial A-frame structure. The area between the collector array and the gymnasium wall, which is enclosed and unconditioned, houses the storage tank, air handling equipment, ductwork, and other solar system components. The storage tank is a partially buried 65 ton pebble bed tank. It is insulated with 2 inches of fiberglass. The pebbles are washed river gravel, 1 to 3 inches in diameter. Domestic hot water is preheated by a cross-flow heat exchanger located in the warm air supply duct and is stored in two 120 gallon, glass-lined, storage tanks. The solar energy system, operational since May 1977, is fully instrumented for performance evaluation and integrated into the National Solar Data Network. DOE

N79-24482# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT COST REPORT: SCATTERGOOD SCHOOL RECREATION CENTER, WEST BRANCH, IOWA

26 May 1978 35 p

(Contracts W-31-109-eng-38; EG-77-C-01-4049)

(SOLAR/2003-78/60) Avail: NTIS HC A03/MF A01

The solar energy system heats approximately 8,000 sq. ft. of recreational (gymnasium) floor space in this one story, metal building. The system utilizes a collector array of 128 modules of air heating, flat plate collectors providing 3496 sq. ft. of area. The planar collector array is supported by a steel frame structure, with the collectors being mounted on 3/4 inches plywood. Energy storage is provided by 1,250 cu. ft. of nominally one to three inch diameter rocks. Service water storage is provided by two 120 gallon glass-lined storage tanks. The construction costs of this solar heating project are presented. Category costs are listed by materials, direct labor and subcontract costs. The subcontract costs include materials, labor, overhead and profit for mechanical and electrical subcontractors only. DOE

N79-24483# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT COST REPORT: TERRELL E. MOSELEY OFFICE BUILDING, LYNCHBURG, VIRGINIA

17 May 1978 35 p

(Contracts W-31-109-eng-38; EG-77-C-01-4049)

(SOLAR/2011-78/60) Avail: NTIS HC A03/MF A01

The construction costs of a solar heating project in an office warehouse building are presented. Category costs are listed by materials, direct labor, and subcontract costs. The subcontract costs include both materials, labor, overhead and profit for mechanical and electrical subcontractors. DOE

N79-24484# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT COST REPORT: KALWALL CORPORATION WAREHOUSE, MANCHESTER, NEW HAMPSHIRE

31 May 1978 29 p

(Contracts W-31-109-eng-38; EG-77-C-01-4049)

(SOLAR/2015-78/60) Avail: NTIS HC A03/MF A01

The construction costs of this solar heating project are presented. Category costs are listed by materials, labor, and subcontract costs. The subcontract costs include both materials, labor overhead and profit for mechanical and electrical subcontractors. DOE

N79-24485# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT DESCRIPTION: ARATEX SERVICES, INCORPORATED, INDUSTRIAL LAUNDRY, FRESNO, CALIFORNIA

7 Jun. 1978 47 p

(Contracts EG-77-C-01-4049; EG-77-C-01-2522)

(SOLAR/2008-78/50) Avail: NTIS HC A03/MF A01

The process water in a large commercial laundering plant in Fresno, California was heated by solar energy. The system utilized 140 Ying, flat plate, lexan glazed collectors which provided an effective aperture area of 6500 square feet. The collectors were mounted in 24 rows on the flat roof of the building. The hot water was stored in a 4000 gallon holding tank to which an immersed heat exchanger added heat from the steam condensate. The solar system was fully instrumented for data acquisition. DOE

N79-24486# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT DESCRIPTION: IRIS IMAGES, INCORPORATED, FILM LABORATORY, MILL VALLEY, CALIFORNIA

9 Jun. 1978 43 p

(Contracts EG-77-C-01-4049; EG-77-C-01-2522)

(SOLAR/2005-78/50) Avail: NTIS HC A03/MF A01

A summary is given of the Iris Images, Inc. solar installation. The solar energy is used to heat photographic process water in a commercial photo-processing laboratory located in Mill Valley, California. The two collector banks are mounted on the flat roof of the building with a total aperture area of 640 square feet. Both of the collector banks were site fabricated. The absorber plates for one bank are aluminum, as manufactured by Sunbrust Solar Energy, Inc. The other absorber plates are copper and were manufactured by Solar Development, Inc. Copper tubing is used for the fluid passages in both collectors. Auxiliary heating of the process water is provided by a gas fired storage type water heater. The solar system has been fully instrumented for data acquisition and is included in the National Solar Data Network. DOE

N79-24487# Louisiana State Univ., Baton Rouge. Inst. for Environmental Studies.

PRELIMINARY LONG-TERM STABILITY CRITERIA FOR COMPRESSED AIR ENERGY STORAGE CAVERNS IN SALT DOMES

R. L. Thoms and J. D. Martinez Aug. 1978 90 p refs

(Contract EY-76-C-06-1830)

(PNL-2871) Avail: NTIS HC A05/MF A01

A methodology for determining the long-term stability of site specific compressed air energy storage cavern systems in salt domes is presented. Results of a literature survey are given. DOE

N79-24488# General Electric Co., Schenectady, N. Y. **EVALUATION OF A FLYWHEEL-POWERED SHUTTLE CAR Final Technical Report as of 25 Aug. 1978**

P. H. Boucheron, Dallas E. Cain, and Allan S. Rubenstein Aug. 1978 335 p

(Contract ET-77-C-01-8890)

(FE-8890) Avail: NTIS HC A15/MF A01

The practical application of flywheel-stored energy devices to shuttle cars in underground coal mining was evaluated along with practical methods of charging, recovery, and transmitting flywheel energy so as to provide power for the necessary functions of a shuttle car. The general conclusions indicate that the mine mission requirements can be fulfilled with a flywheel energy storage system which can be designed within the present state-of-the-art, that a flywheel system can yield sufficient economic benefits to warrant a mine demonstration, and that there is promise of safety improvements due to elimination of the trailing cable presently used. In addition, it is indicated that specific operation problems associated with a flywheel-powered vehicle, like emergency movement of the vehicle and transmission of energy from the wayside to the vehicle, can be satisfactorily solved. DOE

N79-24489# Oak Ridge National Lab., Tenn. Energy Div. **ECONOMETRIC-ENGINEERING ANALYSIS OF FEDERAL ENERGY CONSERVATION PROGRAMS IN THE COMMERCIAL SECTOR**

Jerry R. Jackson Jan. 1979 41 p refs

(Contract W-7405-eng-26)

(ORNL/CON-30) Avail: NTIS HC A03/MF A01

The energy savings and capital cost consequences of four commercial sector conservation programs are reported. The effects of these programs are evaluated using an econometric engineering model of commercial energy use. A baseline projection is developed as the first step in the analysis to determine energy use in the absence of conservation programs. Each conservation program is then evaluated independently and in combination with all other programs. A scenario is developed that removes the effects of market imperfections such as lack of information and

institutional barriers. This perfect-market scenario provides an estimate of the maximum conservation potential in the commercial sector. DOE

N79-24490# Department of Energy, Washington, D. C.
ENERGY MATERIALS COORDINATING COMMITTEE (EMACC) Annual Report, fiscal year 1978

1978 75 p refs
 (Contract W-7405-eng-48)
 (DOE/US-002) Avail: NTIS HC A04/MF A01

Activities in energy-related materials research are presented by members of the DOE Energy Materials Coordinating Committee. DOE

N79-24491# Brookhaven National Lab., Upton, N. Y. Process Sciences Div.

THERMOELECTROCHEMICAL CYCLES FOR POWER AND HYDROGEN PRODUCTION

M. Steinberg 1978 21 p refs Presented at the 2d World Hydrogen Energy Conf., Zurich, 21-24 Aug. 1978
 (Contract EY-76-C-02-0016)
 (BNL-24387; Conf-780807-12) Avail: NTIS HC A02/MF A01

A power cycle for converting thermal to electrical energy is presented. The cycle is referred to as the thermoelectrochemical (TEC) power cycle. The general principle involves combining the electrochemical decomposition of a compound to its elements at a condition where the free energy change is low with the recombination of the same or a different compound from its elements at a condition where the free energy change is high. The difference in free energies gives a net difference in electromotive force which results in a net power output for the system. The power combines the operation of an electrolyzer at a high temperature low emf condition, with a fuel cell at a low temperature high emf condition. The thermal energy is used to provide the high level heat in the electrolyzer while the low level heat is rejected in the fuel cell. Heat is thus converted to dc electricity. Ideal power cycle efficiencies are equal to the Carnot efficiency for non-condensing systems. DOE

N79-24492# Brookhaven National Lab., Upton, N. Y.
HYDROGEN HALOGEN ENERGY STORAGE SYSTEM

P. M. Spaziante (Oronzio de Nora Impianti Elettrochimici S.P.A., Milano, Italy), G. C. Sioli (Oronzio de Nora Impianti Elettrochimici S.P.A., Milano, Italy), R. Trotta (Oronzio de Nora Impianti Elettrochimici S.P.A., Milano, Italy), A. Perego (Oronzio de Nora Impianti Elettrochimici S.P.A., Milano, Italy), and James McBreen 1978 14 p Presented at Chem. Hydrogen Energy Systems Contracts Rev., Washington, D. C., 28 Nov. 1978
 (Contract EY-76-C-02-0016)
 (BNL-25212; Conf-781142-3) Avail: NTIS HC A02/MF A01

The hydrogen/chlorine energy storage system was considered for large scale energy storage. In FY1978 work included an assessment of system safety and cost, investigations of cell performance under conditions elevated pressure and temperature, determination of the transport properties of Nafion membranes and electrochemical engineering studies. Results are summarized. DOE

N79-24493# Energy Systems International, McLean, Va.
SOLAR ENERGY COMMERCIALIZATION FOR EUROPEAN COUNTRIES, VOLUME 2

Dec. 1978 96 p
 (Contract EM-78-C-01-4250)

(HCP/CS-4250-Vol-2) Avail: NTIS HC A05/MF A01

Information was provided for U.S. International Commercialization Planning in the following areas: (1) solar activities and plans of countries visited, (2) near term applications in each country, (3) U.S. export potential in each country, and (4) international cooperation opportunities. The communications infrastructure among all organizations contacted whether U.S. or foreign was developed. Country summaries are provided as an overview of each country visited. DOE

N79-24494# International Business Machines Corp., Huntsville, Ala.
SOLAR PROJECT COST REPORT. IRIS IMAGES, INCOR-

PORATED, FILM LABORATORY, MILL VALLEY, CALIFORNIA

9 Jun. 1978 33 p
 (Contracts W-31-109-eng-38; FG-77-C-01-4049)
 (SOLAR/2005-78/60) Avail: NTIS HC A03/MF A01

The solar energy system which provides preheated process water used for photographic film processing is described. The construction costs of this solar water heating project are presented. Categorical system costs are broken down into materials, direct labor, and subcontract costs where available. DOE

N79-24495# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT COST REPORT. ARATEX SERVICES, INC., INDUSTRIAL LAUNDRY, FRESNO, CALIFORNIA

7 Jun. 1978 35 p
 (Contracts W-31-109-eng-38; EG-77-C-01-4049)
 (SOLAR/2008-78/60) Avail: NTIS HC A03/MF A01

The solar energy system is used in conjunction with a system which recovers heat from laundry wastewater and steam condensate. The construction costs of this solar water heating system are presented. Category costs are listed by materials, labor, and subcontract costs. DOE

N79-24496# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT DESCRIPTION. RADIAN CORPORATION OFFICE BUILDING, AUSTIN, TEXAS

2 May 1978 45 p
 (Contracts EG-77-C-01-4049; EG-77-C-01-2522)
 (SOLAR/2002-78/50) Avail: NTIS HC A03/MF A01

The system utilizes 36 concentrating collectors which provide an effective aperture area of 350 square feet. The collectors are ganged in two banks on the flat roof of the building. An aluminum angle support structure tilts the collectors toward the south and the collectors track the sun for east to west through the day. A tracking mechanism is provided for each of the two banks of collectors. A water/glycol mixture is pumped from the collectors to a counter flow heat exchanger between the collectors and the storage tank. The 1500 gallon insulated, fiberglass storage tank is located above ground on a concrete pad near the building. The cooling equipment for the system is a 3-ton packaged absorption air-cooler located on the second floor of the building and a cooling tower on the roof. DOE

N79-24497# International Business Machines Corp., Huntsville, Ala.

EFFECTS OF AIR DAMPER LEAKS ON SOLAR ENERGY SYSTEM PERFORMANCE

15 Sep. 1978 39 p
 (Contract EG-77-C-01-4049)
 (SOLAR/0012-78/29) Avail: NTIS HC A03/MF A01

The performance of several instrumented solar energy demonstration systems which use air as the energy transport medium was analyzed as part of the National Solar Data Program. Air dampers in all systems were found to leak from 12 to 40 percent of full flow. The investigation into the causes of the leaks is described. An analysis of the potential impact of these leaks on solar energy system performance is presented. Conclusions based on the results of the analysis are given. In the analysis, the impact on system performance was found to be potentially significant. Therefore a set of preventive measures regarding air damper leaks is included. DOE

N79-24498# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT DESCRIPTION. TERRELL E. MOSELEY OFFICE BUILDING, LYNCHBURG, VIRGINIA

17 May 1977 48 p
 (Contracts EG-77-C-01-4049; EG-77-C-01-255)
 (SOLAR/2011-78/50) Avail: NTIS HC A03/MF A01

A summary is given of the Terrell E. Moseley, Inc. Office Building solar installation. The solar energy system for a one story office building in Lynchburg, Virginia, preheats domestic hot water and heats 1780 square feet of occupied space. The 400 square foot collector array was fabricated in a single bank

on the roof of the adjoining warehouse to the solar-conditioned offices. The aluminum absorber plate, painted flat back, is mechanically fastened to a manifolded copper tubing. A thermal mastic is used to improve heat transfer properties between the absorber plate and the tubing. A single glazing of tempered glass covers the absorber plate. The collector back is insulated with a 4 inch thick fiberglass batt. The collector array is mounted on a wooden framing. A 2000 gallon steel storage tank, covered with fiberglass insulation, is located in the warehouse adjoining the solar-conditioned offices. The performance evaluation was integrated into the National Solar Data Network. DOE

N79-24499# International Business Machines Corp., Huntsville, Ala.

SOLAR PROJECT DESCRIPTION. KALWALL CORPORATION WAREHOUSE, MANCHESTER, NEW HAMPSHIRE
31 May 1978 34 p

(Contracts EG-77-C-01-4049; EG-77-C-01-2522)

(SOLAR/2015-78/50) Avail: NTIS HC A03/MF A01

A summary is given of the Kalwall Corporation's solar heated warehouse demonstration project. The direct gain passive solar system was retrofitted to a 10,000 square foot warehouse section in Manchester, New Hampshire. The design used 1750 square feet of Kalwall Corporation's sunwall solar window as the south wall collector aperture. The warehouse's concrete slab floor and inventories provide thermal storage. Five 24-inch thermostatically controlled fans are used for heat circulation. Auxiliary heat is provided by two space heaters supplied by hot water from an oilfire boiler. The solar system was fully instrumented for data acquisition and is included in the National Solar Data Network. DOE

N79-24501# SOLCOST Service Center, Fort Collins, Colo.
SOLCOST: SPACE HEATING HANDBOOK WITH SERVICE NOT WATER AND HEAT LOADS CALCULATIONS
Jul. 1978 25 p

(Contract EX-76-C-01-2531)
(DOE/CS-0042/3) Avail: NTIS HC A02/MF A01

The SOLCOST is a simplified design method for residential and light commercial solar heating and cooling as well as solar hot water systems. It features heat load calculations, solar vs. conventional cost comparison and solar system sizing. Examples using the system are shown. DOE

N79-24503# California Univ., Livermore. Lawrence Livermore Lab.

GENERAL-PURPOSE ALUMINUM-AIR/FLYWHEEL ELECTRIC VEHICLES

J. F. Cooper and E. Behrin 1 Nov. 1978 28 p refs Presented at Fall Meeting of the Electrochem. Soc., Pittsburgh, Pa., Oct. 1978

(Contract W-7405-eng-48)
(UCRL-82003; Conf-7810135-1) Avail: NTIS HC A03/MF A01

Design parameters and optimum operating conditions were determined for aluminum-air/flywheel vehicles with performances equivalent to that of a five-passenger highway automobile. The performance of such vehicles depends strongly on the voltage-current characteristics of aluminum-air cells and the weight of the reactants. The weight of cell hardware constitutes about 5% of the vehicle weight. The weight of the power cell (including reactants and electrolyte) is about 15% of the vehicle gross weight. The total energy cost of propulsion for the aluminum-air vehicle is approximately equal to that of an internal-combustion-engine vehicle of equivalent performance if the primary energy resource in both cases is coal. DOE

N79-24504# Brookhaven National Lab., Upton, N. Y.
GENERAL-EQUILIBRIUM APPROACH TO ENERGY/ENVIRONMENTAL ECONOMIC ANALYSIS

Paul J. Groncki Aug. 1978 23 p refs Presented at the 1978 Ann. Meeting of the Allied Social Sci. Assoc., Chicago, Ill., 29 Aug. 1978

(Contract EY-76-C-02-0016)
(BNL-24781; Conf-780861-1) Avail: NTIS HC A02/MF A01

A brief critique of the use of fixed-coefficient input-output models for use in energy/environment systems is presented. Given the existence of aggregate, general-equilibrium, variable coefficient growth models, a methodology is presented for using this information to adjust a recent disaggregated input-output table. The methodology takes into account all of the general equilibrium aspects of the aggregate model in making the changes in the disaggregate model. The use of various weighting schemes and the implicit technological change biases they embody are examined. The methodology is tested on historical tables for the United States, and preliminary results are discussed. The methodology's ability to fully capture the general-equilibrium nature of the economy should enhance the usefulness of input-output models in energy/environment modeling systems. DOE

N79-24505# Mound Lab., Miamisburg, Ohio.
CHEMICAL AND OPTICAL STUDIES OF HEAT TRANSFER FLUIDS CONTAINING SOLAR ENERGY ABSORBERS

Aaron R. Burke, Claude R. Hudgens, and Layton J. Wittenberg 1978 13 p refs Presented at AICE Meeting, Houston, Tex., 1 Apr. 1979

(Contract EY-76-C-04-0053)
(MLM-2549(OP); Conf-790405-4) Avail: NTIS HC A02/MF A01

Quantitative measurements were made of the increase in absorptivity of the fluids to dissolved chromophoric materials. The heat transfer fluids chosen for this study had the following properties: liquid at ambient temperature, transparent to most of the solar spectrum, and low vapor pressure above the boiling point of water. Such liquids are generally commercially available organic and inorganic heat transfer fluids with potential application to mid-range solar thermal devices. Only chromophoric materials were considered which were soluble in the liquid. DOE

N79-24506# Northwestern Univ., Evanston, Ill.
BASIC RESEARCH ON CERAMIC MATERIALS FOR ENERGY STORAGE AND CONVERSION SYSTEM Progress Report, 1 Dec. 1977 - 30 Nov. 1978

Donald H. Whitmore Dec. 1978 26 p refs
(Contract EY-76-S-02-2564)
(COO-2564-4) Avail: NTIS HC A03/MF A01

Experimental probes are used for measuring the movement of ionic and electronic charge carriers in ceramic materials suitable for solid electrolyte and electrode applications in high-performance secondary battery and fuel cell systems. Special emphasis is placed on developing a better understanding of the effects of structure, impurities and composition on charge carrier transport mechanisms in such materials and detailed knowledge of the kinetics and mechanism of reaction occurring (on a microscopic scale) at the electrode-electrolyte interfaces of energy storage and conversion systems. DOE

N79-24507# California Univ., Berkeley. Lawrence Berkeley Lab.

HYDROCARBONS AND ENERGY FROM PLANTS

Esther K. Nemethy, John W. Otvos, and Melvin Calvin Nov. 1978 10 p refs Presented at Workshop on Biomass Energy and Technol., Santa Clara, Calif., 8-9 Nov. 1978
(Contract W-7405-eng-48)

(LBL-8596; Conf-7811119-1) Avail: NTIS HC A02/MF A01

To explore the feasibility of obtaining fuels and chemical feedstocks by extraction of reduced photosynthetic materials from latex-bearing plants, field studies were undertaken in the cultivation and harvesting of Euphorbia lathyrus, a shrub that grows wild in the California climate. Preliminary results with wild seed and without the benefit of optimization of fertilizer and irrigation conditions gave an annual crop yield of about 12 dry tons per acre. Continuing agronomic studies are suggested for improving this yield. Reduced photosynthate can be extracted with various solvents from the plant material to the extent of 8.7 percent of dry plant weight. The extract is a complex mixture, averaging between 400 and 500 in molecular weight. DOE

N79-24508# Argonne National Lab., Ill.
DESIGN OF OPTIMUM COMPRESSED AIR ENERGY STORAGE SYSTEMS

A. Sharma (Ill. Univ. at Chicago Circle), F. W. Ahrens, K. M. Ragsdell (Purdue Univ.), R. K. Ahluwalia, and H. H. Chik (Ill. Univ. at Chicago Circle) 1978 43 p refs Presented at 1978 Midwestern Energy Conf., Chicago, 19-21 Nov. 1978 (Contract W-31-109-eng-38)

(CONF-781101-1) Avail: NTIS HC A03/MF A01

Compressed air energy storage (CAES) power systems are considered by electric utilities for load-leveling application. Their economic benefit and the extent of premium fuel conservation is dependent on their design. An optimum design approach for CAES is presented. It is based on decomposition of the overall CAES plant/utility grid system into three partially-decoupled sub-systems. Technical and economic models of the subsystems are used in a constrained optimization procedure. The constraints are imposed by the physical characteristics of the subsystems, by interaction among the subsystems and by the interfacing requirements imposed by the utility. To illustrate the concepts, models for the subsystem comprising the compressor train, piping, and an aquifer reservoir was used in the optimization procedure. Results show that substantial reductions in capital cost and total operating cost can be achieved using optimization techniques. DOE

N79-24509# Brookhaven National Lab., Upton, N. Y. National Center for Analysis of Energy Systems.

METHOD FOR THE COMPARATIVE ECONOMIC ASSESSMENT OF ENERGY STORAGE SYSTEMS

H. Davitian and R. W. Leigh Nov. 1978 18 p refs Presented at Intersoc. Energy Conversion Eng. Conf., San Diego, Calif., Oct. 1978

(Contract EY-76-C-02-0016)

(BNL-25291; Conf-7810142-1) Avail: NTIS HC A02/MF A01

A method for the comparative economic evaluation of various energy storage devices in a given application is outlined. The method is used in examining the economics of devices with short lifetimes and can be employed whenever a device lifetime can be expressed as a function of physical parameters which are related to the manner in which the device is used. The economic consequences of changes in lifetime result from the dependence of the capital recovery factor on device lifetime. It is shown how analyses can be made of changes in technical performance characteristics or changes in the pattern of use of the storage device to determine their effects upon the annual cost of energy storage and to determine minimum cost systems. DOE

N79-24510# Sandia Labs., Albuquerque, N. Mex.
RESEARCH AT SANDIA LABORATORIES FOR SOLAR THERMAL LARGE POWER SYSTEMS PROGRAM Annual Summary, fiscal year 1978

Feb. 1979 60 p refs

(Contract EY-76-C-04-0700)

(SAND-78-8051) Avail: NTIS HC A04/MF A01

The technical activities performed at Sandia Laboratories in support of the Large Power systems portion of the Solar Thermal Power Program are summarized. Heliostat development, thermal storage research, receiver development, and system studies are described. DOE

N79-24511# Sandia Labs., Albuquerque, N. Mex.
PHOTOVOLTAIC CONCENTRATOR SYSTEM TECHNOLOGY AND APPLICATIONS EXPERIMENTS

E. L. Burgess 1979 10 p refs Presented at ASME Gas Turbine Closed-Cycle Sess., San Diego, Calif., 11 Mar. 1979 (Contract EY-76-C-04-0789)

(SAND-78-2184; Conf-790305-2)

Avail: NTIS HC A02/MF A01

Photovoltaic systems offer the potential of providing a significant portion of the nation's electrical energy needs by converting solar energy directly into electrical energy. The major obstacle preventing this potential from being realized is the cost of photovoltaic systems. One approach to reducing system cost

is to concentrate sunlight on the photovoltaic cells, increasing their output and hence, decreasing the amount of cell area required for a given power output. Technology is described and its future potential is discussed. Brief summaries of several concentrator applications experiments which are in the system design phase are presented. DOE

N79-24512# Edgerton, Germeshausen and Grier, Inc., Albuquerque, N. Mex.

PERFORMANCE TESTING OF THE MCDONNELL DOUGLAS FRESNEL LENS SOLAR COLLECTOR

Vernon E. Dudley and Robert M. Workhoven Feb. 1979 31 p refs

(Contract EY-76-C-04-0789)

(SAND-78-0625) Avail: NTIS HC A03/MF A01

The results of tests performed on the McDonnell Douglas Fresnel Lens rotating array solar collector at the Midtemperature Solar Systems test facility are summarized. Test objectives are defined, procedures are described, and conclusions are given. DOE

N79-24513# National Oceanic and Atmospheric Administration, Silver Spring, Md. Air Resources Lab.

RELATIVE EFFECTIVE SOLAR SPACE HEATING OVER THE UNITED STATES OBTAINED FROM SOUTHWARD-TILTED SOLAR COLLECTORS

Walter H. Hoecker Nov. 1978 20 p refs

(PB-292963/6; NOAA-TM-ERL-ARL-73; NOAA-79020801)

Avail: NTIS HC A02/MF A01 CSCL 10A

The distribution of relative effective solar space heating is displayed on maps of the contiguous United States for January and for the November through April heating maps are based on climatological data updated to 1978 and flat solar energy collectors tilted southward at angles of location latitude plus 10 degrees where average ground reflectivity is assumed. GRA

N79-24514# Wayne State Univ., Detroit, Mich.

CUPROUS OXIDE PHOTOVOLTAIC CELLS Final Report, 1 Oct. 1975 - 31 Mar. 1978

Dan Trivich, Edward Y. Wang, and Richard J. Komp Jul. 1978 75 p refs

(Grant NSF AER-75-23453)

(PB-290529/7; NSF/RA-780383)

Avail: NTIS

HC A04/MF A01 CSCL 10B

Schottky barrier front-wall Cu₂O photovoltaic cells were prepared for the first time with different metals on isolated sheets of polycrystalline and single crystal Cu₂O. The starting Cu₂O material is prepared by heating sheet copper in air at 1000C. The polycrystalline Cu₂O sheet can be converted into single crystal sheet by grain growth at 1070-1120C. Annealing at 500C improves the conductivity. After suitable etching and other surface treatment, the Cu₂O sheet is coated with a thin film of metal by vacuum evaporation to produce the frontwall cell. A series of metal contacts were studied. A best cell of Cu/Cu₂O under simulated sunlight gave a short-circuit current of 7 mA/sq cm, an open-circuit potential of 0.35 V and a fill factor of 0.45 for a conversion efficiency of 1.1%. From an analysis of the current-voltage curves, barrier heights were evaluated for the various metal/Cu₂O junctions. GRA

N79-24515# Iowa Inst. of Hydraulic Research, Iowa City.
OPTIMUM COMBINATIONS OF COOLING ALTERNATIVES FOR STREAM-ELECTRIC POWER PLANTS, VOLUME 2 Final Report

Thomas E. Croley, Arthur R. Giaquinta, Rosa M.-H. Lee, and Tai-Dan Hsu Jul. 1978 185 p refs

(Contract DI-14-31-0001-5201)

(PB-290576/8; IHR-212-Vol-2; W79-03662;

OWRT-C-6011(5201)(3)-Vol-2) Avail: NTIS HC A09/MF A01 CSCL 10B

Cooling alternatives and system thermodynamics are presented. Two sets of computer models are developed for the analysis through combination cooling systems. The models are used to study the thermal characteristics, economics, and water consumption of these combination cooling systems. The effects of both meteorological conditions and economic parameters such

as various unit costs, were examined in the identification of optimum cooling system configurations for several case studies. The most promising cooling system configurations or types of combined cooling - systems, which are attractive in their economic or water conservation aspects were determined. It is found that the parallel water path configuration of the wet tower/cooling pond combination cooling system is economically superior to the series water path configurations. Finally, it is evident that combination wet lower/once-through cooling systems are economical in comparison with once-through cooling associated with low river heat assimilation capacity. GRA

N79-24517# California Energy Commission, Sacramento.
FEASIBILITY AND ECONOMICS OF COGENERATION IN CALIFORNIA'S THERMAL ENHANCED OIL RECOVERY OPERATIONS Final Report
Dec. 1978 203 p refs
(PB-291794/6; CAEC-21) Avail: NTIS HC A10/MF A01 CSCL 10B

The large quantities of steam injected into oil wells to increase production by the process of thermal enhanced oil recovery (EOR) can also be used to generate electricity at some sites. Which California oil fields are suitable for cogeneration, the generation capacity possible, the appropriate fuel, and the economics of coal use for noncogeneration steam production at oil fields were determined. GRA

N79-24518# EIC, Inc., Newton, Mass.
ENERGY STORAGE WITH AMBIENT TEMPERATURE RECHARGEABLE LITHIUM BATTERIES Final Report, 1 Apr. 1975 - 31 Dec. 1977
S. B. Brummer, F. W. Dampier, V. R. Koch, R. D. Rauh, and T. F. Reise Jan. 1978 284 p refs
(Grant NSF AER-75-03779)
(PB-290934/9; NSF/RA-780382) Avail: NTIS HC A13/MF A01 CSCL 10C

An ambient temperature rechargeable lithium battery with characteristics suitable for load-levelling and electric vehicle applications was developed. The battery was to use an organic electrolyte and a dissolved depolarizer. Transition metal depolarizers were studied. Their major problem was excessive self-discharge. The depolarizer of choice is lithium/polysulfide, which is very soluble and discharges and recharges readily. Its self-discharge reaction with lithium is slow and leads to soluble lower polysulfides. The initial problems of this system which operates a little above room temperature (approximately 50 C) were moderate rate capability and modest recharging of the lithium electrode. Improvements in the cycling performance were in large part due to the development and refinement of techniques for the preparation of high purity electrolyte. GRA

N79-24519# California Energy Commission, Sacramento.
INVENTORY OF UNDERGROUND ENERGY STORAGE SITES IN CALIFORNIA Final Staff Report
Melissa Ann Jones Oct. 1978 99 p refs
(PB-290835/8; CAEC-32) Avail: NTIS HC A05/MF A01 CSCL 10A

Compressed air and pumped hydropower, heat from solar thermal systems, and natural gas and petroleum products can be stored underground. Gas fields, oil fields, saline aquifers, hard rock sites, caves and abandoned mines with minimum storage volumes of five million cubic feet and maximum depths of 3,500 feet are identified as potential energy storage sites. Data collected on compressed air energy storage sites in California is included and supplemented by information on California oil and gas fields. The information given for each site includes: the site name, location, depth to storage medium, volume, rock type, rock thickness, permeability, porosity, pressure containment capacity, and distance to transmission facilities, pipelines and geologic hazards. GRA

N79-24520# Geiringer (Paul L.) and Associates, Roslyn, N. Y.
COMMUNITY APPLICATION OF INTEGRATED ENERGY/UTILITY SYSTEMS
Oct. 1978 34 p refs Sponsored in part by NBS and DOE

(Contract DHEW-100-77-0014)

(PB-290675/8) Avail: NTIS HC A03/MF A01 CSCL 13A
Sufficient information is provided for prospective Integrated Energy Utility System (IEUS) participants to determine the feasibility of an IEUS project that would fit their specific needs. Past studies made at the University of Florida and Central Michigan are summarized and the Burlington, Vermont study is examined in detail for lessons learned and recommendations on how to design and implement a successful IEUS project. GRA

N79-24534# TRW, Inc., Durham, N. C.
DEMONSTRATION OF WELLMAN-LORD/ALLIED CHEMICAL FGD TECHNOLOGY: ACCEPTANCE TEST RESULTS
R. C. Adams, S. J. Lutz, and S. W. Mulligan Jan. 1979 129 p refs
(Contract EPA-68-02-1877)
(PB-290514/9; EPA-600/7-79-014A) Avail: NTIS HC A07/MF A01 CSCL 13A

Process performance guarantees were met or exceeded. During the 12-day Design Load test, the plant was operated at the design condition of a boiler flue gas output rate equivalent to 80 percent of the maximum boiler load of 115 MW gross. During the 83-hour High Load test, the plant treated flue gas volumes equivalent to 95 percent of maximum boiler load. SO₂ removal of 90 percent or better was achieved. Particulate emissions did not exceed 0.1 lb/million Btu of boiler heat input. The consumption of steam, natural gas, and electrical power was less than the performance guarantee requirements at Design Load conditions. Soda ash consumption was less than the limit set by the performance guarantees. Finally, sulfur product purity was greater than 99.5 percent. GRA

N79-24535# Automation Industries, Inc., Silver Spring, Md. Vitro Labs. Div.
ENERGY/ENVIRONMENT 3: PROCEEDINGS OF THE 3RD NATIONAL CONFERENCE ON THE INTERAGENCY R AND D PROGRAM
Oct. 1978 363 p refs Conf. held at Washington, D. C., 1-2 Jun. 1978
(Contract EPA-68-01-2934)
(PB-290558/6; EPA-600/9-78-022) Avail: NTIS HC A16/MF A01 CSCL 13B

Energy/Environment 3 provides an update of Interagency research programs in particular areas, including health effects, transport processes and ecological effects, mining methods and reclamation, control technology and integrated technology assessment. Complete texts of all papers are presented, along with addresses, panel discussions, and question and answer periods. GRA

N79-24537# Environmental Protection Agency, Research Triangle Park, N.C. Office of Air Quality Planning and Standards.
CONTROL OF VOLATILE ORGANIC EMISSIONS FROM PETROLEUM LIQUID STORAGE IN EXTERNAL FLOATING ROOF TANKS
Richard K. Burr, Kerri C. Brothers, and Jack G. Wright Dec. 1978 64 p refs
(PB-290579/2; EPA-450/2-078-047; OAQPS-1.2-116) Avail: NTIS HC A04/MF A01 CSCL 13B

The necessary guidance for development of regulations limiting emissions of volatile organic compounds (VOC) from storage of petroleum liquids in external floating roof tanks is presented in this report. Reasonably available control technology (RACT) is defined in this document; cost analysis for RACT is included for evaluating the cost effectiveness of controlling external floating roof tank sources. GRA

N79-24543# Denver Research Inst., Colo.
BALLOON-BORNE PARTICULATE SAMPLING FOR MONITORING POWER PLANT EMISSIONS Final Report, Nov. 1978 - Jul. 1978
J. A. Armstrong, P. A. Russell, and R. E. Williams Oct. 1978 60 p refs

(Grant EPA-R-804829)
(PB-290473/8; EPA-600/7-78-205) Avail: NTIS
HC A04/MF A01 CSCL 14B

A light weight remote-controlled sensor sampler, carried aloft by a tethered balloon, that was developed to collect particulates from the plumes of fossil fuel power plants at various downwind distances, is presented. The airborne sampler is controlled from the ground by a radio transmitter and receiver/servo system. The sampler system was field tested at two sites burning low-sulfur coal, an urban and a rural power plant. The collected samples were analyzed in terms of size, concentration, and composition using scanning electron microscopy/energy dispersive X-ray spectrometry. In general, the particles were spheres with diameters less than 5 micrometers. Some agglomerates were found. Most of the fly ash was composed of Si and Al, with small amounts of Fe. GRA

N79-24592# Bundesanstalt fuer Geowissenschaften und Rohstoffe, Hannover (West Germany).

RESULTS OF THE GEOSCIENTIFIC INVESTIGATIONS FROM THE VALDIVA CRUISE VA-10/1975 OFF WESTERN AFRICA

Juergen Fritsch, Karl Hinz, Ulrich vonRad, Hans-Albert Roeser, Gerd Wissman, and Wilfried Weigel Bonn Bundesmin. fuer Forsch. u. Technol. Jul. 1978 60 p refs In GERMAN; ENGLISH summary Sponsored by Bundesmin. fuer Forsch. u. Technol. Prepared jointly with Hamburg Univ.

(BMFT-FB-M-78-03) Avail: NTIS HC A04/MF A01; Fachinformationzentrum Karlsruhe, West Ger. DM 12.40

Precise information, garnered from refraction gravitational measurements and geological samples, was obtained for two regions: Cape Verde Rise to Mauritania; Gran Canaria Island to Cape Bojador/Western Sahara. Sediments up to 10 km thick were proved to exist in a crustal section extending to the Mohorovicic discontinuity off Mauritania. Jurassic and Cretaceous sediments with seismic velocities typical for evaporitic and carbonate facies form a lens several kilometers thick under the upper rise. Pronounced irregularities in seismic records suggest a high degree of episodic erosion of the continental margin. Oil conditions are shown to exist off Mauritania and Senegal (near a Cretaceous carbon platform) and off the Western Sahara (near an anticline of Cretaceous sediments). Author (ESA)

N79-24621# Hawaii Univ., Honolulu. Dept. of Civil Engineering.

WIND ENGINEERING RESEARCH DIGEST, VOLUME 3, 1978 Periodic Report, 1975 - 1978

Arthur N. L. Chiu Nov. 1978 174 p refs

(Grant NSF ENG-76-19806)

(PB-290694/9) Avail: NTIS HC A08/MF A01 CSCL 04B

Reports of ongoing research activity in environmental aerodynamics throughout the United States are presented. Topic areas discussed include the following: structure of wind; wind-wave effects; effects on urban areas; wind loading on structures; severe storms; design for hurricanes and tornadoes; full-scale testing; model testing; environmental factors; psychophysical factors; legal factors; special problems; wind considerations in urban planning; building codes and regulations; socio-economic effects; international cooperation; and wing energy. GRA

N79-24626# Oak Ridge National Lab., Tenn.

EMERGENCE OF BIOTECHNOLOGY

Charles D. Scott 1978 26 p refs Presented at 16th Ann. New Horizons of Sci. Briefing, Gatlinburg, Tenn., 13 Nov. 1978 (Contract W-7405-eng-26)

(TID-28983) Avail: NTIS HC A03/MF A01

A brief review is given of recent new developments in biotechnology. The characteristics of bioprocesses discussed include specificity, isolation of the biological agent, and sophistication, and scale of bioprocesses. Examples of new areas of application of biotechnology are bioconversion of organic wastes to fuels or chemical feedstocks, resource recovery, and biophotolysis. DOE

N79-24813 Virginia Polytechnic Inst. and State Univ., Blacksburg. **A DYNAMIC MULTI-CRITERIA ANALYSIS OF SPENT-NUCLEAR-FUEL ALTERNATIVES** Ph.D. Thesis

Robert William Langham, II 1978 310 p

Avail: Univ. Microfilms Order No. 7910714

A generalized multiple-objective research and development (R & D) capital budgeting model incorporating production-allocation decisions is developed for the analysis of the spent-nuclear-fuel management problem. The generalized model is decomposed into a multiple-objective R & D capital budgeting problem and a multiple-objective fuel allocation problem. Goal programming is selected as an appropriate modeling technique for both generic models. The spent-nuclear-fuel-allocation problem is further decomposed into a dynamic program with a goal program at each stage. The objectives are to allocate R & D funds to process or technology development and to allocate spent fuel to certain alternatives so as to minimize the weighted and prioritized vector cost. Dissert. Abstr.

N79-24877# California Univ., Livermore. Lawrence Livermore Lab.

SYSTEMATIC COMPUTATION OF THE PERFORMANCE OF PHOTOVOLTAIC BASED ON FIRST PRINCIPLES

J. H. Yee 29 Jan. 1979 38 p refs

(Contract W-7405-eng-48)

(UCID-1804-Pt-1; Rept-1) Avail: NTIS HC A03/MF A01

The minority lifetime and the minority diffusion length were theoretically estimated for both the single crystal and polycrystalline film of Cu₂S, Cu₂O, and CdTe. The mobility of the electron as a function of the temperature was calculated for the Cu₂O single crystal based upon the simple model of the electron-polar optical phonon interaction. It was shown that the existing data on the hole mobility of Cu₂S can be explained very well by a simple model of grain boundary scattering. The effect of impurity and defect on the minority carrier lifetime and the minority diffusion length was discussed. A model for the energy structure of Cu₂S was proposed. This energy band model explains very well the experimental data for the absorption coefficient. DOE

N79-24899# Argonne National Lab., Ill.

ENVIRONMENTAL DEVELOPMENT PLAN FOR TRANSPORTATION ENERGY CONSERVATION. FY 1979 UPDATE

M. K. Singh and M. J. Bernard, III 15 Dec. 1978 157 p refs

(Contract W-31-109-eng-38)

(ANL/EES-TM-33) Avail: NTIS HC A08/MF A01

This first annual update of the Environment Development Plan (EDP) identifies the ecosystem, resource, physical environment, health, safety, and socioeconomic concerns associated with the division's transportation programs. These programs include the research, development, demonstration and assessment of seventeen transportation technologies and several strategy and policy development and implementation projects. The transportation technologies projects deal with highway transport including electric vehicles, marine transport and pipeline transport. This EDP presents a research and assessment plan for resolving any potentially adverse environmental concerns stemming from these programs. DOE

N79-24900# Department of Energy, Washington, D. C. Transportation Energy Conservation Div.

ELECTRIC AND HYBRID VEHICLE PROGRAM Annual Report to Congress, fiscal year 1978

Jan. 1979 90 p refs

(DOE/CS-0068; AR-2) Avail: NTIS HC A05/MF A01

The DOE Electric and Hybrid Vehicle Program has responsibility for accelerating the commercialization of electric and hybrid vehicles in the nation's transportation sector. The goal of the program is to assure the availability and broad market acceptance of vehicles that do not depend on petroleum as their principal energy source. The program management, demonstrations (P. L. 94-413 requirements), incentives, research and development, risk assessment, impact assessments, and environmental impact evaluation processes are discussed. DOE

N79-24946# Joint Publications Research Service, Arlington, Va.

TRANSLATIONS ON USSR SCIENCE AND TECHNOLOGY: PHYSICAL SCIENCES AND TECHNOLOGY, NO. 67

7 May 1979 42 p Transl. into ENGLISH from various Russian journals

(JPRS-73388) Copyright. Avail: NTIS HC A03/MF A01

News releases from the Soviet Union are presented. Topics include better utilization of data processing centers and automated control systems, as well as improved efficiency in producing electricity.

N79-24949# Joint Publications Research Service, Arlington, Va.

POWER INDUSTRY APPLICATION OF MHD TECHNOLOGY

A. Sheyndlin *In its* Transl. on USSR Sci. and Technol.: Phys. Sci. and Technol., No. 67 (JPRS-73388) 7 May 1979 p 19-22 Transl. into ENGLISH from Izvestiya (Moscow), 30 Mar. 1979 p 3

Copyright. Avail: NTIS HC A03/MF A01

Various economic developments in the Soviet Union are discussed, concerning the increased requirements and production of electricity. The main concern is better utilization of available fuels, such as natural gas, crude oil, nuclear energy, etc. J.A.M.

N79-24980*# National Aeronautics and Space Administration, Langley Research Center, Hampton, Va.

A COOLING SYSTEM FOR AN AIRCRAFT HAVING A CRUISE RANGE FROM MACH 2 TO MACH 8 Patent Application

Pierce L. Lawing and Laverne L. Pagel, inventors (to NASA) (McDonnell Aircraft Co.) Filed 31 Jan. 1979 21 p (NASA-Case-LAR-12406-1; US-Patent-Appl-SN-008210) Avail: NTIS HC A02/MF A01 CSCL 01C

The necessity of shielding an aircraft airframe constructed of material such as aluminum is eliminated by using a system which provides total cooling for an airframe designed to fly in the speed range of Mach 2 to Mach 8. Cooling is accomplished by passing a coolant through the aircraft airframe, the coolant acting as a carrier to remove heat from the airframe. The coolant is circulated through a heat pump and a heat exchanger which together extract essentially all of the added heat from the coolant. The heat is transferred to the aircraft fuel system via the heat exchanger and the heat pump. The heat extracted from the coolant is utilized to power the heat pump. The heat pump is associated with a power turbine mechanism which is also driven by the extracted heat. The power turbines are utilized to drive various aircraft subsystems, the compressor of the heat pump, and provide engine cooling. This system is accomplished with a small increase in aircraft weight and a total result of a small increase in performance. NASA

N79-25040# Transportation Systems Center, Cambridge, Mass. **THE AIRPORT PERFORMANCE MODEL VOLUME 1: EXTENSIONS, VALIDATIONS, AND APPLICATIONS** Final Report, Jan. 1975 - Jun. 1976

J. Bellantoni, H. Condell, I. Englander, L. Fuentes, and J. Schwenk Oct. 1978 285 p refs

(AD-A062863; TSC-FAA-78-21-1) Avail: NTIS HC A13/MF A01 CSCL 01/5

A computer simulation of airport delay and congestion was prepared to help evaluate the benefit of capacity-related investments in the nation's airports. The model which has a data base comprising 31 high density airports, estimates dollar benefits to passengers and aircraft operators or delay reduction in landing, takeoff and gate docking, and reduction in fuel consumed and pollutants emitted as well as required groundside facilities. The delay estimate from the model showed reasonably good agreement with data taken at JFK, LGA and EWR. It was used to evaluate proposed investments for Honolulu, Detroit and Charlotte, N. C. GRA

N79-25243# Southwest Research Inst., San Antonio, Tex. Army Fuels and Lubricants Research Lab.

CRUDE AND PRODUCT STORAGE: STATE-OF-THE-ART REVIEW AND ASSESSMENT Final Report, Jun. - Nov. 1978

J. N. Bowden and L. L. Stavinocha Nov. 1978 74 p refs

(Contracts DAAK70-78-C-0001; EL-78-A-01-2185)

(AD-A066605; AFLRL-110) Avail: NTIS HC A04/MF A01 CSCL 15/5

National policy has dictated that large reserves of petroleum be stored in order to diminish U. S. vulnerability to the effects of a severe petroleum supply interruption. To ensure that products being considered for storage would be of a quality immediately usable and to identify likely quality assurance procedures, an investigation program was undertaken. The first task under this program was to review and assess the state-of-the-art in petroleum crude and product storage. Through literature review, questionnaires, and personal contacts, considerable information was identified for use in programs relating to the effect of storage on the quality of finished petroleum products. As a result of this task, it has been determined that underground storage of refined distillate products can be accomplished with proper selection of products to be stored, through specification requirements, quality control/surveillance, and judicious use of additives. Author GRA

N79-25248# Department of Energy, Bartlesville, Okla. Energy Technology Center.

NATIONAL MOTOR GASOLINE SURVEYS: A KEY SOURCE OF FUEL TREND DATA

H. J. Coleman, E. M. Shelton, and C. J. Thompson Aug. 1978 18 p refs

(BETC/RI-78/16) Avail: NTIS HC A02/MF A01

The characteristics, properties, and quality of both winter and summer motor gasolines as obtained on samplings from all 17 major marketing districts of the United States are presented. Data and fuel trends useful for fuel and engine improvements and development of meaningful fuel specifications are provided. The reporting of motor gasoline quality provides some bases for extrapolating to the desired and/or required octane number rating of fuels in the 1980's. DOE

N79-25249# Aerodyne Research, Inc., Bedford, Mass.

AN ASSESSMENT OF THE POTENTIAL IMPACT OF COMBUSTION RESEARCH ON INTERNAL COMBUSTION ENGINE EMISSIONS AND FUEL CONSUMPTION Final Report, Dec. 1977 - Apr. 1978

J. L. Kerrebrock and C. E. Kolb Jan. 1979 92 p refs

(Contract DOT-TSC-1487)

(PB-290953/9; ARI-RR-131; DOT-HS-803-722;

DOT-TSC-NHTSA-78-47) Avail: NTIS HC A05/MF A01 CSCL 21D

The basic thermodynamic, fluid dynamic, and chemical kinetic processes which affect the fuel economy and levels of pollutant exhaust products of diesel, stratified charge, and spark ignition engines are reviewed. Key areas are identified where insufficient understanding currently prevents the rational development of internal combustion engines with improved performance. A research plan designed to gather the needed data is presented. GRA

N79-25311*# National Aeronautics and Space Administration, Pasadena Office, Calif.

SCHOTTKY BARRIER CELL AND METHOD OF FABRICATING IT Patent Application

Richard J. Stirn (JPL) and Yea-Chuan M. Yeh, inventors (to NASA) (JPL) Filed 29 Sep. 1977 25 p Sponsored by NASA

(NASA-Case-NPO-13689A; US-Patent-Appl-SN-837513) Avail: NTIS HC A02/MF A01 CSCL 09A

A low cost Schottky barrier type solar cell is described. The prior active layer substrate is replaced with an inexpensive semiconductor polycrystalline substrate on which the active layer is grown, eliminating the need for a single crystal wafer. The methods of forming native and nonnative interfacial oxide layers is presented. M.M.M.

N79-25337# National Bureau of Standards, Washington, D. C. National Engineering Lab.

SEMICONDUCTOR TECHNOLOGY PROGRAM, PROGRESS BRIEFS Interim Report, Apr. - Jun. 1978

W. Murray Bullis, ed. Oct. 1978 16 p Sponsored by DOE, DNA, and AFAL

(ARPA Order 2397)

(PB-292681/4; NBSIR-78-1444-3)

Avail: NTIS

HC A02/MF A01 CSDL 09B

Information on the current status of NBS work in measurement technology for semiconductor materials, process control, and devices is reported. The activities include: (1) determination of resistivity dopant density relationships in silicon; (2) measurement of ion implanted dopant profiles by spreading resistance; (3) optical measurement of line widths on chrome photomasks, iron oxide photomasks, and silicon wafers; (4) sulfur impurity levels in silicon; (5) stability of thin solar cells; (6) radiation dose incurred by oxide layers during X-ray and e-beam lithographs; and (7) rectifier diode wafers. Contacts for obtaining further information are listed. GRA

N79-25360# National Technical Information Service, Springfield, Va.

HEAT PIPES, VOLUME 3. CITATIONS FROM THE ENGINEERING INDEX DATA BASE Progress Report, Apr. 1977 - Mar. 1979

William E. Reed Apr. 1979 214 p Supersedes NTIS/PS-78/0304; NTIS/PS-76/0251

(NTIS/PS-79/0299/2; NTIS/PS-78/0304; NTIS/PS-76/0251)

Avail: NTIS HC \$28.00/MF \$28.00 CSDL 13A

Research reports covering the thermodynamics, design, fabrication, and applications of heat pipes are cited from worldwide literature. Applications are described in the areas of electronics cooling, spacecraft thermal control, heat exchangers, heating and refrigeration, and waste heat utilization. This updated bibliography contains 208 abstracts, 77 of which are new entries to the previous edition. GRA

N79-25361# National Technical Information Service, Springfield, Va.

HEAT PIPES VOLUME 3. CITATIONS FROM THE NTIS DATA BASE Progress Report, Mar. 1976 - Mar. 1979

William E. Reed Apr. 1979 254 p Supersedes NTIS/PS-78/0302; NTIS/PS-77/0275; NTIS/PS-76/0249; NTIS/PS-75/317

(NTIS/PS-79/0298/4; NTIS/PS-78/0302; NTIS/PS-77/0275; NTIS/PS-76/0249; NTIS/PS-75/317) Avail: NTIS

HC \$28.00/MF \$28.00 CSDL 13A

Theory, design, fabrication, testing, and operation of heat pipes are presented in these Federally-sponsored research reports. Applications are described in the areas of heating and air conditioning power generation, electronics cooling, spacecraft, nuclear reactors, cooling engines, and thermodynamics. This updated bibliography contains 247 abstracts, 77 of which are new entries to the previous edition. GRA

N79-25396# Rockwell International Corp., Canoga Park, Calif. Rocketdyne Div.

INTEGRATED POWER UNIT Final Report, 16 Apr. 1976 - 31 Jul. 1978

G. S. Wong, T. I. Yu, J. J. Ward, R. L. Binsley, and J. A. Williams Dec. 1978 253 p

(Contract F33615-76-C-2054; AF Proj. 3145)

(AD-A066543; RI/RD78-237; AFAPL-TR-78-98) Avail: NTIS HC A12/MF A01 CSDL 21/5

Results of a development program for an Integrated Power Unit (IPU) combining the functions of the Accessory Power Units (APU) and Emergency Power Units (EPU) for the aircraft are presented. The design and testing of two gas generators using gaseous oxygen (GOX) and JP-4 propellants are discussed. Subsequent design and test results for an IPU engine starter demonstrator that used one of the gas generators are also presented. GRA

N79-25443* National Aeronautics and Space Administration, Marshall Space Flight Center, Huntsville, Ala.

COAL-SHALE INTERFACE DETECTION Patent

Peter H. Broussard, John L. Burch, Edward J. Drost, and Richard J. Stein, inventors (to NASA) Issued 15 May 1979 8 p Filed 3 Nov. 1977

(NASA-Case-MFS-23720-3; US-Patent-4,154,084;

US-Patent-Appl-SN-848420; US-Patent-Class-73-12;

US-Patent-Class-73-82) Avail: US Patent and Trademark Office CSDL 08I

A penetrometer for coal-shale interface detection is presented. It is used with coal cutting equipment consisting of a reciprocating hammer, having an accelerometer mounted thereon to measure the impact of the hammer as it penetrates the ceiling or floor surface of a mine. Additionally, a pair of reflectometers simultaneously view the same surface, and the outputs from the accelerometer and reflectometers are detected and jointly registered to determine when an interface between coal and shale is being cut through.

Official Gazette of the U.S. Patent and Trademark Office

N79-25445 Colorado School of Mines, Golden.

A STUDY OF THE PHYSICAL AND CHEMICAL PROPERTIES OF OIL SHALE RELEVANT TO PHYSICAL CONCENTRATION PROCESSES Ph.D. Thesis

Donald James Kaczynski 1977 220 p

Avail: Univ. Microfilms Order No. 7912216

The physical and surface chemical properties of an oil shale relevant to physical concentration processes were studied, with a view to applications of such processes. Complete liberation was not achieved, even for particles in the low micron size range, and the preferential breakage of the high-grade organic portion of the materials into coarse, flat particles in the treatment of more conventional ores. Treatment of a -3/8 inch feed in a heavy medium of s.g. 2.3 resulted in the recovery of 80 percent of the organics in 50 percent of the original weight. Treating a -10 mesh feed on a shaking table gave slightly inferior results. Separation in an upward flowing water current was not an effective concentration process, but indicated the superiority of classification over screening in any proposed closed grinding circuit. Dissert. Abstr.

N79-25446*# Mississippi State Univ., Mississippi State.

APPLICATION OF REMOTE SENSING TO STATE AND REGIONAL PROBLEMS Semiannual Progress Report, 1 Nov. 1978 - 30 Apr. 1979

W. Frank Miller, Principal Investigator, Dale A. Quattrochi, Bradley D. Carter, Gary K. Higgs, Jimmy L. Solomon, and Charles L. Wax 1 May 1979 101 p refs Original contains color imagery. Original photography may be purchased from the EROS Data Center, Sioux Falls, S. D. 57198 ERTS

(Grant NGL-25-001-054)

(E79-10196; NASA-CR-158510; SAPR-11) Avail: NTIS HC A06/MF A01 CSDL 05A

The author has identified the following significant results. The Lowndes County data base is essentially complete with 18 primary variables and 16 proximity variables encoded into the geo-information system. The single purpose, decision tree classifier is now operational. Signatures for the thematic extraction of strip mines from LANDSAT Digital data were obtained by employing both supervised and unsupervised procedures. Dry, blowing sand areas of beach were also identified from the LANDSAT data. The primary procedure was the analysis of analog data on the I2S signal slicer.

N79-25469# General Electric Co., Schenectady, N. Y.

HIGH-GRADIENT MAGNETIC SEPARATION FOR REMOVAL OF SULFUR FROM COAL Final Report, 1 Mar. 1976 - 31 Jan. 1977

F. E. Luborsky Nov. 1978 90 p refs Sponsored in part by EPA and DOE

(Contract DI-BM-HO-366008)

(PB-290945/5; EPA-600/7-78-208; FE-8969-1) Avail: NTIS HC A05/MF A01 CSDL 08I

Results of a thorough physical, chemical, and magnetic characterization of a Pennsylvania coal from the Upper Freeport seam are given. The powdered coal was then subjected to

high-gradient magnetic separations, as a function of slurry and an air dispersion. Ash and pyritic sulfur reductions occurred with increasing magnetic field intensities and decreasing fluid velocities. The best results were obtained in water slurries where approximately 50 percent of the total sulfur and 50 percent of the ash were removed. Air dispersions produced insignificant results.

GRA

N79-25479* New Mexico Univ., Albuquerque. Technology Application Center.

SOLAR THERMAL COMPONENTS: A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, Oct. - Dec. 1978

Apr. 1979 78 p Sponsored by NASA
(NASA-CR-158699) Avail: NTIS HC A05 for foreign requestors only. Domestic orders, Univ. of New Mexico, Tech. Application Center, Albuquerque CSCL 10A

The final issue of the 1978 bibliographic series is presented. The update to Solar Thermal Components cites additional references identified during the fourth quarter (October-December) of 1978.

G.Y.

N79-25480* New Mexico Univ., Albuquerque. Technology Application Center.

SOLAR THERMAL HEATING AND COOLING: A BIBLIOGRAPHY WITH ABSTRACTS Quarterly Update, Oct. - Dec. 1978

Apr. 1979 90 p refs Sponsored by NASA
(NASA-CR-158693) Avail: NTIS HC A05 for foreign requestors only. Domestic orders, Univ. of New Mexico, Tech. Application Center, Albuquerque CSCL 10A

The fourth and last issue of in the 1978 bibliographic series is presented. The volume, as well as the two companion volumes, presents the latest published research in the field of solar energy.

G.Y.

N79-25482* National Aeronautics and Space Administration. Pasadena Office, Calif.

DOUBLE-SIDED SOLAR CELL PACKAGE Patent

Benjamin Shelpuk, inventor (to NASA) (JPL) Issued 8 May 1979 8 p Filed 29 Mar. 1978 Supersedes N78-22470 (16 - 13, p 1719) Sponsored by NASA

(NASA-Case-NPO-14199-1; NASA-Case-NPO-14200-1; US-Patent-4,153,476; US-Patent-Appl-SN-891243; US-Patent-Class-136-89PC; US-Patent-Class-136-89SJ; US-Patent-Class-136-89CC; US-Patent-Class-136-89CA) Avail: US Patent and Trademark Office CSCL 10A

In a solar cell array of terrestrial use, an improved double-sided solar cell package, consisting of a photovoltaic cell having a metallized P-contact strip and an N-contact grid, provided on opposite faces of the cell, a transparent tubular body forming an enclosure for the cell. A pedestal supporting the cell from within the enclosure comprising an electrical conductor connected with the P-contact strip provided for each face of the cell, and a reflector having an elongated reflective surface disposed in substantially opposed relation with one face of the cell for redirecting light were also included.

Official Gazette of the U.S. Patent and Trademark Office

N79-25484* Spire Corp., Bedford, Mass.

DEVELOPMENT OF PULSED PROCESSES FOR THE MANUFACTURE OF SOLAR CELLS Interim Report

John A. Minnucci Dec. 1978 215 p refs Prepared for JPL and DOE

(Contract JPL-954786)
(NASA-CR-158706; IR-1; DOE/JPL-954786-78/06A; IR-77-10052-1) Avail: NTIS HC A10/MF A01 CSCL 10A

The results of a 1-year program to develop the processes required for low-energy ion implantation for the automated production of silicon solar cells are described. The program included: (1) demonstrating state-of-the-art ion implantation equipment and designing an automated ion implanter, (2) making efforts to improve the performance of ion-implanted solar cells to 16.5 percent AM1, (3) developing a model of the pulse annealing process used in solar cell production, and (4) preparing an economic analysis of the process costs of ion implantation.

G.Y.

N79-25485* OAO Corp., Beltsville, Md.

PROCEEDINGS OF THE US DOE PHOTOVOLTAICS TECHNOLOGY DEVELOPMENT AND APPLICATIONS PROGRAM REVIEW

1978 334 p refs Conf. held in Arlington, Va., 7-9 Nov. 1978 Prepared for DOE

(Contracts NAS7-100; JPL-BB-689-604)
(NASA-CR-158682; Conf-781191) Avail: NTIS HC A15/MF A01 CSCL 10A

Research in Photovoltaics and its applications is reported.

N79-25486* Aerospace Corp., El Segundo, Calif.

PHOTOVOLTAIC MISSION ANALYSIS

S. L. Leonard /in OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-1 - 1-15

Avail: NTIS HC A15/MF A01 CSCL 10A

Photovoltaic analysis was used to support the planning, development, and guidance of the National Photovoltaic program. The analysis identified and evaluated: (1) photovoltaic applications likely to have major energy impact; (2) appropriate strategies for stimulating the growth of photovoltaic markets; and (3) critical issues, define scope of subsequent examinations.

S.E.S.

N79-25487* Massachusetts Inst. of Tech., Cambridge. Energy Lab.

PLANNING AND ANALYSIS FOR DEVELOPMENT OF PHOTOVOLTAIC ENERGY CONVERSION SYSTEMS

Richard D. Tabors /in OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-16 - 1-22

Avail: NTIS HC A15/MF A01 CSCL 10A

The project areas discussed include: (1) demand and decision analysis; (2) market analysis; (3) institutional analysis; (4) social cost analysis; and (5) performance and standard analysis. S.E.S.

N79-25488* Sandia Labs., Albuquerque, N. Mex.

A SUMMARY OF SYSTEMS DEFINITION PROJECT ACTIVITIES Photovoltaic Systems Definition Project

Gary J. Jones and Kent L. Biringner /in OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-23 - 1-91

Avail: NTIS HC A15/MF A01 CSCL 10A

Design information and subsystem requirement definition to the overall program is presented. Application analysis and conceptual design for the wide variety of systems, system tradeoff studies and engineering design for the more promising application types, and the identification of the technology status and requirements for major subsystems and components are described. The residential design and analysis contracts, hybrid photovoltaic/solar thermal electric conversion contract, and development of prototype combined photovoltaic/thermal flat-plate collectors were studied.

S.E.S.

N79-25489* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

LOW-COST SOLAR ARRAY PROJECT

W. T. Callaghan /in OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-93 - 1-121

Avail: NTIS HC A15/MF A01 CSCL 10A

Technology development and technical feasibility are reviewed. Process and materials candidates to meet project goals were investigated. Integration of technical development with cost estimates is discussed.

S.E.S.

N79-25490* Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.

LSA ENGINEERING STATUS Low-cost Solar Array Project

R. Ross /in OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-122 - 1-131

Avail: NTIS HC A15/MF A01 CSCL 10A

Module engineering activities, environmental testing in research and development, and module requirement generation are discussed in the solar array project. S.E.S.

N79-25491*# Sandia Labs., Albuquerque, N. Mex.
STATUS OF THE DOE PHOTOVOLTAIC CONCENTRATOR DEVELOPMENT PROJECT Low-cost Solar Array Project
 D. G. Schueler / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-139 - 1-165 Sponsored by DOE

Avail: NTIS HC A15/MF A01 CSCL 10A

Photovoltaic concentrator technology resulting in low cost, long-life photovoltaic arrays at a price of less than \$0.50 per peak watt by 1986 was developed. Concentrator concepts are identified which have the highest potential for low-cost long life by supporting concept development and evaluation, improving solar array manufacturing technology and by increasing solar array production capacity and quantity. S.E.S.

N79-25492*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.
DOE PHOTOVOLTAIC TESTS AND APPLICATIONS PROJECT

Ron Cull and Tony Ratajczak / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-166 - 1-179

Avail: NTIS HC A15/MF A01 CSCL 10A

The installation date, system and location, and solar arrays are tabulated. S.E.S.

N79-25493*# Lincoln Lab., Mass. Inst. of Tech., Lexington.
SOLAR PHOTOVOLTAIC FIELD TESTS AND APPLICATIONS PROJECT

Ron Matlin / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-181 - 1-194

Avail: NTIS HC A15/MF A01 CSCL 10A

Technical credibility of solar cell power systems is presented. The reduction costs for photovoltaic power systems is discussed. Field tests in the residential demand sector were conducted. S.E.S.

N79-25494*# Army Mobility Equipment Research and Development Center, Fort Belvoir, Va.

MILITARY APPLICATIONS OF PHOTOVOLTAIC SYSTEMS
 Donald D. Faehn / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-195 - 1-209

(Contract E(49-26)-1031)

Avail: NTIS HC A15/MF A01 CSCL 10A

Applications of solar cell power systems at military facilities are presented. The construction and purpose of these different field test facilities are discussed. S.E.S.

N79-25495*# Solar Energy Research Inst., Golden, Colo. Photovoltaic Program Office.

PHOTOVOLTAIC RESEARCH AND DEVELOPMENT STATUS

D. L. Feucht / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-211 - 1-223

Avail: NTIS HC A15/MF A01 CSCL 10A

The goals of the Photovoltaic R&D Program are to develop thin film semiconductor and novel photovoltaic conversion concepts, and to demonstrate the feasibility of producing these cells for a price of \$100 - \$300 per peak electric output (in 1975) by FY1985. The approaches that are used to determine which research should be funded are formal solicitations, an innovative concepts program which will be launched in FY79, and the review of unsolicited proposals. Author

N79-25496*# Arizona Public Service Co., Phoenix.
PHOTOVOLTAICS AND ENVIRONMENTAL IMPACT

CONSIDERATIONS Airport Solar Photovoltaic Concentrator Project

Eric R. Weber / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-225 - 1-267

Avail: NTIS HC A15/MF A01 CSCL 10A

An analysis and description is presented for the proposed Airport Solar Photovoltaic Concentrator Project. The environmental effects and potential impacts of the test facilities are discussed. S.E.S.

N79-25497*# United Nations, New York, N. Y.

CHARACTERISTICS OF A TYPICAL VILLAGE IN THE SOLAR BELT OF THE DEVELOPING COUNTRIES OF ASIA, AFRICA, AND LATIN AMERICA

I. H. Usmani / In OAO Corp. Proc. of the US DOE Photovoltaics Technol. Develop. and Appl. Program Rev. 1978 p 1-269 - 1-283 refs

Avail: NTIS HC A15/MF A01 CSCL 10A

The economic development of a typical village is presented. The village requirements, basic energy needs of the village, and financing of rural electrification programs are discussed. S.E.S.

N79-25498*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

GAS-TURBINE CRITICAL RESEARCH AND ADVANCED TECHNOLOGY SUPPORT PROJECT Annual Report, FY 1978

John S. Clark, Carl E. Lowell, Richard W. Niedzwiecki, and Joseph J. Nainiger Jun. 1979 46 p refs

(Contract EF-77-A-01-2593)

(NASA-TM-79139; DOE/NASA/2593-79/6; E-9986) Avail: NTIS HC A03/MF A01 CSCL 10B

The technical progress made during the first 15 months of a planned 40-month project to provide a critical-technology data base for utility gas-turbine systems capable of burning coal-derived fuels is summarized. Tasks were included in the following areas: (1) combustion, to study the combustion of coal-derived fuels and conversion of fuel-bound nitrogen to NO_x; (2) materials, to understand and prevent hot corrosion; and (3) system studies, to integrate and guide the other technologies. Significant progress was made. G.Y.

N79-25499*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

MHD PERFORMANCE CALCULATIONS WITH OXYGEN ENRICHMENT

C. C. P. Pian, P. J. Staiger, and G. R. Seikel 1979 32 p refs Presented at 18th Symp. on Engineering Aspects of Magnetohydrodynamics, Butte, Montana, 18-20 Jun. 1979

(Contract EF-77-A-01-2674)

(NASA-TM-79140; DOE/NASA/2674-79/4; E-9987) Avail: NTIS HC A03/MF A01 CSCL 10A

The impact of oxygen enrichment of the combustion air on the generator and overall plant performance was studied for the ECAS-scale MHD/steam plants. A channel optimization technique is described and the results of generator performance calculations using this technique are presented. Performance maps were generated to assess the impact of various generator parameters. Directly and separately preheated plant performance with varying O₂ enrichment was calculated. The optimal level of enrichment was a function of plant type and preheat temperature. The sensitivity of overall plant performance to critical channel assumptions and oxygen plant performance characteristics was also examined. Author

N79-25500*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

COMMERCIAL PHOSPHORIC ACID FUEL CELL SYSTEM TECHNOLOGY DEVELOPMENT

Paul R. Prokopius, Marvin Warshay, Stephen N. Simons, and Robert B. King 1979 9 p refs Proposed for presentation at the 14th Intersociety Energy Conversion Engr. Conf., Boston, Mass., 5-10 Aug. 1979

(Contract DE-AI-03-79ET11272)

(NASA-TM-79169; DOE/NASA/11272-79/1; E-034) Avail: NTIS HC A02/MF A01 CSCL 10C

Reducing cost and increasing reliability were the technology drivers in both the electric utility and on-site integrated energy system applications. The longstanding barrier to the attainment of these goals was materials. Differences in approaches and their technological features, including electrodes, matrices, intercell cooling, bipolar/seperator plates, electrolyte management, fuel selection, and system design philosophy were discussed. Author

N79-25501* National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOCIAL AND ECONOMIC IMPACT OF SOLAR ELECTRICITY AT SCHUCHULI VILLAGE

William J. Bifano, Anthony F. Ratajczak, Donald M. Bahr (Arizona State Univ., Tempe), and Billy G. Garrett (Arizona State Univ., Tempe) 1979 18 p refs Presented at the Seminar on Solar Technol. in Rural Settings: Assessments of Field Experiences, Atlanta, Ga., 1-2 Jun. 1979; sponsored by United Nations Univ.

(Contract DE-AI-01-79ET20485)

(NASA-TM-79194; DOE/NASA/20485-79/3; E-071) Avail: NTIS HC A02/MF A01 CSCL 10A

Schuchuli, a small remote village on the Papago Indian Reservation in southwest Arizona, is 27 kilometers (17 miles) from the nearest available utility power. Its lack of conventional power is due to the prohibitive cost of supplying a small electrical load with a long-distance distribution line. Furthermore, alternate energy sources are expensive and place a burden on the resources of the villagers. On December 16, 1978, as part of a federally funded project, a solar cell power system was put into operation at Schuchuli. The system powers the village water pump, lighting for homes and other village buildings, family refrigerators and a communal washing machine and sewing machine. J.A.M.

N79-25503* Contemporary Systems, Inc., Jaffrey, N. H. **SOLAR HEATING SYSTEM FINAL DESIGN PACKAGE**

May 1979 69 p Prepared for DOE

(Contract: NAS8-32243)

(NASA-CR-161228) Avail: NTIS HC A04/MF A01 CSCL 10A

The system is composed of a warm air collector, a logic control unit and a universal switching and transport unit. The collector was originally conceived and designed as an integrated roof/wall system and therefore provides a dual function in the structure. The collector serves both as a solar energy conversion system and as a structural weather resistant skin. The control unit provides totally automatic control over the operation of the system. It receives input data from sensor probes in collectors, storage and living space. The logic was designed so as to make maximum use of solar energy and minimize use of conventional energy. The transport and switching unit is a high-efficiency air-handling system equipped with gear motor valves that respond to outputs from the control system. The fan unit was designed for maximum durability and efficiency in operation, and has permanently lubricated ball bearings and excellent air-handling efficiency. R.E.S.

N79-25504* Northrup, Inc., Hutchins, Tex. **CERTIFICATION AND VERIFICATION FOR NORTHRUP MODEL NSC-01-0732 FRESNEL LENS CONCENTRATING SOLAR COLLECTOR**

Mar. 1979 181 p Prepared for DOE

(Contract NAS8-32251)

(NASA-CR-161164) Avail: NTIS HC A09/MF A01 CSCL 10A

Structural analysis and certification of the collector system is presented. System verification against the interim performance criteria is presented and indicated by matrices. The verification discussion, analysis, and test results are also given. R.E.S.

N79-25505* Spectrolab, Inc., Sylmar, Calif. **SILICON SOLAR CELL PROCESS DEVELOPMENT, FABRICATION AND ANALYSIS** Quarterly Report, 28 Aug. - 31 Dec. 1978

1978 10 p Prepared for JPL and DOE

(Contract JPL-955055)

(NASA-CR-158700; DOE/JPL-955055-78/1; JPL-9950-51;

QR-1) Avail: NTIS HC A02/MF A01 CSCL 10A

A program plan, baseline process, measurement program and quality control plan were generated. Cutting operations were completed on the silicon sheet material. The first fabrication run of polycrystalline silicon into solar cells by baseline process was completed. Average conversion efficiency for solar cells fabricated by the baseline process from sheet and measured at air mass zero was 10.4%, compared with the control cells, fabricated from single crystal CZ silicon, whose average conversion efficiency was 12.2%. G.Y.

N79-25506* Pennsylvania Univ., Philadelphia. School of Electrical Engineering.

ANALYSIS AND EVALUATION OF PROCESSES AND EQUIPMENT IN TASKS 2 AND 4 OF THE LOW-COST SOLAR ARRAY PROJECT Quarterly Report, Oct. 1977 - Jan. 1978

H. Goldman and M. Wolf Aug. 1978 118 p refs Sponsored by NASA Prepared for JPL

(Contract JPL-954796)

(NASA-CR-158681; DOE/JPL-954796-77/1; JPL-9950-61) Avail: NTIS HC A06/MF A01 CSCL 10A

Several experimental and projected Czochralski crystal growing process methods were studied and compared to available operations and cost-data of recent production Cz-pulling, in order to elucidate the role of the dominant cost contributing factors. From this analysis, it becomes apparent that the specific add-on costs of the Cz-process can be expected to be reduced by about a factor of three by 1982, and about a factor of five by 1986. A format to guide in the accumulation of the data needed for thorough techno-economic analysis of solar cell production processes was developed. Author

N79-25507* Hughes Research Labs., Malibu, Calif.

LOW ENERGY PROTON RADIATION DAMAGE TO (AlGa)As-GaAs SOLAR CELLS Final Report, 5 Jul. 1978 - 5 Jan. 1979

Robert Loo, Sanjiv Kamath, and Ronald Knechtli Jan. 1979 106 p refs

(Contract NAS1-15443)

(NASA-CR-159040) Avail: NTIS HC A06/MF A01 CSCL 10A

Twenty-seven 2 times 2 sq cm (AlGa)As-GaAs solar cells were fabricated and subjected to 50 keV, 100 keV, and 290 keV of proton irradiation along with eighteen high efficiency silicon solar cells. The results of the study further corroborate the advantages for space missions offered by GaAs cells over state of the art silicon cells. Thus, even though the GaAs cells showed greater degradation when irradiated by protons with energy less than 5 MeV, the solar cells were normally protected from these protons by the glass covers used in space arrays.

The GaAs cells also offered superior end of life power capability compared with silicon. The change in the open circuit voltage, short circuit current, spectral response, and dark 1-5 characteristics after irradiation at each proton energy and fluence were found to be consistent with the explanation of the effect of the protons. Also dark 1-5 characteristics showed that a new recombination center dominates the current transport mechanism after irradiation. Author

N79-25508* Comptroller General of the United States, Washington, D.C.

LIQUEFIED ENERGY GASES SAFETY. VOLUME 1: EXECUTIVE SUMMARY AND MAIN TEXT Report to the Congress

31 Jul. 1978 618 p refs 3 Vol.

(EMD-78-28-Vol-1) Avail: NTIS MF A01; HC SOD

Liquefied Energy Gas (LEG) safety issues, problem areas, and the actions taken to protect the public were examined. Data are discussed on: (1) LEG storage facilities; (2) LEG transportation; (3) the potential consequences; (4) liability, research, and regulation; and (5) General Accounting Office's recommendations. S.E.S.

N79-25509# Comptroller General of the United States, Washington, D.C.

LIQUEFIED ENERGY GASES SAFETY. VOLUME 2: APPENDIXES Report to the Congress

31 Jul. 1978 470 p refs 3 Vol.
(EMD-78-28-Vol-2) Avail: NTIS MF A01; HC SOD

Listings contained include: (1) the contractors and consultants interviewed, and (2) the facilities and organizations visited. The calculations and experiments are discussed to verify certain assumptions and answers. S.E.S.

N79-25510# Comptroller General of the United States, Washington, D.C.

LIQUEFIED ENERGY GASES SAFETY. VOLUME 3: FEDERAL AGENCY COMMENTS Report to the Congress

31 Jul. 1978 176 p refs 3 Vol.
(EMD-78-28-Vol-3) Avail: NTIS MF A01; HC SOD

Comments made by the Departments of Commerce, Energy, State, and Transportation, the Interstate Commerce Commission, and the National Transportation Safety Board are reported. Disagreements with many of comments are discussed. S.E.S.

N79-25513# Committee on Science and Technology (U. S. House).

OVERSIGHT ON PHOTOVOLTAIC ENERGY CONVERSION

Washington GPO 1978 140 p refs Hearing before the Subcomm. on Advanced Energy Technologies and Energy Conservation Res., Development and Demonstration of the Comm. on Sci. and Technol., 95th Congr., 1st Sess., 9 Sep. 1977 (GPO-31-624) Avail: Subcomm. on Advanced Energy Technologies and Energy Conservation Res., Development and Demonstration

The technology of photovoltaic array conversion is assessed. Emphasis is placed on reviewing the status of the Low Cost Silicon Solar Array Project. A plan is described of a draft proposal (restructuring an existing program plan) which attempts to improve the odds of reaching a goal of 50 cents per peak watt by 1986. G.Y.

N79-25514# Hughes Aircraft Co., Los Angeles, Calif. Space and Communications Group.

HIGH EFFICIENCY GaAs SOLAR CELL DEVELOPMENT Final Report, 1 Aug. 1976 - 1 Jul. 1978

S. Kamath and G. Wolff Jan. 1979 103 p refs
(Contract F33615-76-C-2121)
(AD-A066616; AFAPL-TR-78-96) Avail: NTIS
HC A06/MF A01 CSCL 10/2

Gallium arsenide solar cells were optimized to improve radiation resistance of the cell without loss of efficiency, thus improving the suitability of the cell for space missions. J.M.S.

N79-25516# Army Construction Engineering Research Lab., Champaign, Ill.

THE PERFORMANCE OF AN EXPERIMENTAL SOLAR HEATING SYSTEM

D. M. Joncich, D. J. Leverenz, and D. L. Johnson Feb. 1979 26 p refs

(DA Proj. 4A7-62731-AI-41)
(AD-A066699; CERL-IR-E-144) Avail: NTIS
HC A03/MF A01 CSCL 13/1

This report describes the performance of a residential-scale, completely instrumented solar heating system located at the U.S. Army Construction Engineering Research Laboratory (CERL), Champaign, Ill. The investigation was made between January 1977 and April 1978. In addition, a daily profile of the performance of the system and its components is presented for a representative sunny winter day. An analysis of the solar system operation indicated that the collector array is by far the most inefficient component in the system for converting incident solar energy into useful heat. The solar system consists of 20 sq m (220 sq ft) of flat-plate, selective surface, singly glazed solar collectors and a 7.6 cu m (2000 gal) equivalent hot water storage tank. The storage system supplies hot water for heating a 50 sq m (540 sq ft) building used by CERL as office space. There is no domestic hot water in the building. Auxiliary energy is supplied by an electric, flow-through hot water heater. The results of

this research are presented in terms of mean daily averages for each month during the heating season and include instantaneous solar radiation (horizontal and in the plane of the collector), useful heat acquired by the collector, useful heat delivered to the thermal storage tank, useful heat delivered to the heating load, thermal storage heat losses, and electrical energy supplied to the pumps. Author (GRA)

N79-25517# Naval Ocean Systems Center, San Diego, Calif.
PERFORMANCE OF PHOTOVOLTAIC CELLS IN AN UNDERSEA ENVIRONMENT Final Report, Mar. - Oct. 1978

J. D. Stachiw 1 Jan. 1979 44 p refs
(ZF61512001)
(AD-A066385; NOSC/TR-359) Avail: NTIS
HC A03/MF A01 CSCL 10/2

Photovoltaic solar cells can serve as a reliable source of electric power for electronic instrumentation in temporarily or permanently submerged marine systems in the form of bottom installations, buoys, or remotely controlled unmanned vehicles. The power output of submerged solar cells is a function of solar insolation intensity on the water surface, depth of submersion, optical properties of water, temperature, and the orientation of the cell surface with respect to the sun. Experimental data were generated by submerging solar cell panels in different bodies of water with a 2.5- to 95-ft visual contrast limit, as defined by the observation of a submerged, standard, 12-in Secchi disc, and measuring their performance under load. The power output of horizontally oriented, upward-facing, photovoltaic cells submerged to the visual contrast limit depth was found to be a constant, equal to approximately 5 to 10 percent of the power generated by upward-facing, horizontally oriented cells in an atmospheric environment. The power output of the cells increased at lesser depths, until in the splash zone the output was essentially the same or higher than in the atmospheric environment. Based on these findings it can be concluded that high-efficiency silicon solar cells can serve as a practical electrical power supply in electronic devices for marine applications, if their depth of submersion is less than the visual contrast limit at the dive location. GRA

N79-25519# Edgerton, Germeshausen and Grier, Inc., Albuquerque, N.Mex.

PERFORMANCE TESTING OF THE GENERAL ATOMIC FIXED MIRROR SOLAR CONCENTRATOR

V. E. Dudley and R. M. Workhoven (Sandia Labs., Albuquerque, N. Mex.) May 1978 35 p refs
(Contract EY-76-C-04-0789)
(SAND-78-0624) Avail: NTIS HC A03/MF A01

The testing which was performed on the General Atomic Fixed Mirror Solar Concentrator at the Midtemperature Solar Systems Test Facility is summarized. Test objectives are defined, test procedures are described, and results and conclusions are given. DOE

N79-25520# Edgerton, Germeshausen and Grier, Inc., Albuquerque, N.Mex.

CONCENTRATING SOLAR COLLECTOR TEST RESULTS FROM DOE/SANDIA COLLECTOR MODULE TEST FACILITY

V. E. Dudley and R. M. Workhoven 1978 7 p refs Presented at Sem. on Testing Solar Energy Materials and Systems, Washington, D. C., 22 May 1978 Prepared in cooperation with Sandia Labs., Albuquerque
(Contract EY-76-C-04-0789)
(SAND-78-0881C; Conf-780550-6) Avail: NTIS
HC A02/MF A01

A series of concentrating solar collectors are being tested in the Collector Module Test Facility (CMTF). The objective of the test series is to characterize the performance of concentrating solar collectors. Of primary concern is the peak thermal efficiency at solar noon and receiver thermal losses of these collectors over the temperature range from about 100 to 300 C. Five collectors were tested from August 1977 to January 1978, and results of these tests are reported. DOE

N79-25521# Department of Energy, Washington, D. C. Div. of Solar Applications Developments.

SOLAR TECHNOLOGY TRANSFER PROGRAM

Mar. 1978 53 p

(DOE/CS-0027/1) Avail: NTIS HC A04/MF A01

Widespread commercialization of solar energy is discussed. Specific topics covered include: (1) national laboratories regional outreach; (2) installer training and education; (3) information dissemination; (4) workshops, conferences, and exhibits; and (5) consumer representation. DOE

N79-25522# Little (Arthur D.), Inc., Cambridge, Mass.

SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB) COMMERCIALIZATION REPORT, PART B, ANALYSIS OF MARKET DEVELOPMENT. VOLUME 1: EXECUTIVE SUMMARY, SEPTEMBER 1977

May 1978 25 p Sponsored by DOE

(HCP/M70066-01/1-Vol-1) Avail: NTIS HC A02/MF A01

A quantitative model is described which is capable of generating market penetration figures for the solar heating and cooling of buildings under a wide range of assumptions. The results of the model are analyzed and compared with various solar incentive scenarios and data base assumptions.

Author (DOE)

N79-25523# Little (Arthur D.), Inc., Cambridge, Mass.

SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB) COMMERCIALIZATION REPORT, PART B, ANALYSIS OF MARKET DEVELOPMENT. VOLUME 3: APPENDICES, SEPTEMBER 1977

Mar. 1978 58 p Sponsored by DOE

(HCP/M70066-01/3-Vol-3) Avail: NTIS HC A04/MF A01

Appendices are presented which support the analysis of incentives for accelerated commercialization of solar heating and cooling of buildings in the residential and commercial sectors.

DOE

N79-25524# Austrian Solar and Space Agency, Vienna.

METEOROLOGICAL MEASUREMENT DATA FOR SOLAR ENERGY UTILIZATION [METEOROLOGIE MESSDATEN FUER DIE NUTZUNG DER SONNENENERGIE]

G. Braeunlich, M. Bruck, E. Panzhauser, F. Neuwirth, and G. Skoda (Vienna Univ.) Mar. 1977 108 p refs In GERMAN Sponsored by Bundesmin. fuer Wiss. U. Forsch. Prepared in cooperation with Zentralanstalt fuer Meteorol. U. Geodyn., Vienna

(ASSA-FA-5) Avail: NTIS HC A06/MF A01

Meteorological parameters relevant to solar energy utilization are defined. Topics discussed include an empirical procedure for approximation of total radiation, an inventory of available measurement data, recommendations for an expanded program of measurement, and standardized data acquisition and data processing. It is concluded that relevant data are available at only a few observation points and the available data are not fully evaluated with respect to requirements of solar energy users. Appropriate measures are proposed to reduce the data deficit. The meteorological parameters necessary for a precise determination of total radiation are listed. Time series analysis of radiation and meteorological data for Central Austria and computer storage of these data is recommended in support of a program simulating performance of a solar energy system. J.M.S.

N79-25526# Austrian Solar and Space Agency, Vienna.

COMPARISON OF COLLECTOR TEST METHODS [VERGLEICH VON KOLLEKTOR-TESTMETHODEN]

P. Varga (Tech. Univ., Vienna) and M. Bruck Dec. 1977 17 p In GERMAN

(ASSA-SE-B24/77) Avail: NTIS HC A02/MF A01

Test methods introduced by the U.S. National Bureau of Standards, the American Society of Heating, Refrigerating, and Air Conditioning Engineers, the West German Labor Council for Solar Energy, and the Swiss Society for Solar Energy are compared with respect to measured variable, procedure specifications, and evaluation of the variables. The variables compared in tabular form are solar irradiation, ambient temperature, wind speed, temperature heat transfer medium, temperature difference at the

collector, pressure and pressure differential, and flow rate. Collector and auxiliary equipment specifications are compared in separate tables. Conditions of an indoor test with a solar simulator are tabulated. J.M.S.

N79-25527# Austrian Solar and Space Agency, Vienna.

SOLAR ENERGY MEASURING STATIONS IN AUSTRIA: RESULTS AND EXPERIENCES [SONNENENERGIE - MESSSTATIONEN IN OESTERREICH: ERGEBNISSE UND ERFAHRUNGEN]

Jun. 1978 71 p In GERMAN

(ASSA-SE-INFO-6/78) Avail: NTIS HC A04/MF A01

Solar test stations equipped by the Austrian Federal Ministry of Science and Research are described. The test stations are used to evaluate technological and economic possibilities of direct conversion of solar radiation energy into low temperature heat for swimming pools, houses, and research institutes. Outdoor solar collectors are used for long and short term tests. Results and conclusions drawn from the tests are summarized. It is indicated that standardization of data acquisition and fully automated data recording are the absolute prerequisites for long term observation of polyvalent solar heating systems. Consequently, an instrument package was developed for data acquisition and evaluation. Industrial production of similar instruments was also planned. J.M.S.

N79-25528# Austrian Solar and Space Agency, Vienna.

GLOBAL RADIATION ON RANDOMLY ORIENTED AND INCLINED SURFACES IN AUSTRIA [DIE GLOBALSTRahlung AUF BELIEBIG ORIENTIERTE UND GENEIGTE EBENEN IN OESTERREICH]

M. Bruck, W. Heindl, F. Neuwirth (Zentralanstalt fuer Meteorol. U. Geodyn., Vienna), and G. Schaffar (Tech. Univ., Vienna) Jul. 1978 27 p refs In GERMAN

(ASSA-SE-INFO-7/78) Avail: NTIS HC A03/MF A01

A procedure for the calculation of the correction factor R for global solar radiation on a horizontal surface is described. This factor is used to calculate global radiation on inclined and randomly oriented surfaces, taking into account reflectivity of the terrestrial environment. The estimated reflection coefficients of different surfaces are tabulated. The R values averaged over several months are calculated and compared with the experimental R values for various locations. The calculated average R values are tabulated versus sea level and collector inclination and orientation. J.M.S.

N79-25529# Austrian Solar and Space Agency, Vienna.

THERMAL UTILIZATION OF SOLAR ENERGY IN AUSTRIA. PART 1: HOT WATER PREPARATION, SWIMMING POOL AND SPACE HEATING [THERMISCHE NUTZUNG DER SONNENENERGIE IN SCHWIMMBADHEIZUNG, RAUM-HEIZUNG]

Gerhard Faninger and Manfred Bruck Bundesmin. fuer Wiss. U. Forsch. Oct. 1978 90 p In GERMAN

Avail: NTIS HC A05/MF A01

Possibilities and limitations of solar energy technology are discussed, along with meteorological prerequisites for solar energy conversion to heat. Construction and characteristics of solar collectors are detailed, as well as systems for heat generation. Design methods and architectural aspects are briefly reviewed. J.A.M.

N79-25530# Bundesministerium fuer Wissenschaft und Forschung, Vienna (Austria). Research Dept.

SOLAR STREAM IN AUSTRIA [SOLARSTROM IN OESTERREICH]

Norbert Weyss 1977 72 p refs In GERMAN

Avail: NTIS HC A04/MF A01

The procedure for electricity generation in so-called solar power plants combined with pump storage stations is shown. Terrestrial and solar energy sources were considered, along with various possibilities of solar energy utilization, land procurement for energy utilization, and economics of solar power plants. The mechanical power requirement of a solar-hydraulic supply system was examined. Costs of solar power plants vs. fossil fuel plants were estimated. J.A.M.

N79-25531# New Mexico Univ., Albuquerque. Technology Application Center.

FORECASTS OF ENERGY TECHNOLOGY. CITATIONS FROM THE INTERNATIONAL AEROSPACE ABSTRACTS DATA BASE Progress Report, 1974 - Dec. 1978

Gerald F. Zollars Apr. 1979 47 p Sponsored by NTIS (NTIS/PS-79/0337/0) Avail: NTIS HC \$28.00/MF \$28.00 CSCL 10A

The cited articles from worldwide literature concern forecasts of the development of energy technology. Stressed are forecasts relating to new energy sources such as hydrogen-based energy, solar energy conversion and nuclear energy and coal utilization. Economic analyses of various energy conversion techniques are included. GRA

N79-25533# American Physical Society, New York, N. Y. **PRINCIPAL CONCLUSIONS OF THE AMERICAN PHYSICAL SOCIETY STUDY GROUP ON SOLAR PHOTOVOLTAIC ENERGY**

16 Jan. 1979 196 p refs Sponsored in part by DOE (Contract OSTP-77-13)

(PB-292164/1) Avail: NTIS HC A09/MF A01 CSCL 10B

Those aspects related to solar photovoltaic energy conversion which are of interest to the Department of Energy and the wider technical community are discussed. These include silicon-based and thin-film based solar cell technology, concentrators, systems considerations, perspective on long-term research programs, and some comments on funding formats. GRA

N79-25535# International Science and Technology Inst., Inc., Washington, D. C.

POTENTIAL USE OF SMALL DAMS TO PRODUCE POWER FOR LOW-INCOME COMMUNITIES

Mary M. Allen 4 Aug. 1978 220 p Prepared in cooperation with Polytechnic Inst. of New York, Brooklyn (Contract CSA-B88-5584)

(PB-292745/7) Avail: NTIS HC A10/MF A01 CSCL 10B

An alternative source of energy which would have a stable cost and alleviate the economic strain of rising fossil fuels is the development of small dam sites to produce hydroelectric power. The many issues involved in estimating the potential contribution of hydropower to the energy supply are addressed. The issues discussed include: (1) physical characteristics, (2) environmental and safety considerations, (3) institutional constraints, (4) economic issues, and (5) current governmental programs. GRA

N79-25536# California State Univ., Fullerton.

AN EVALUATION OF THE HYDROTHERMAL RESOURCES OF THE DESERT HOT SPRINGS REGION, CALIFORNIA Final Report

Brent F. Russell Feb. 1979 87 p refs Sponsored by the California Energy Commission, Sacramento

(PB-290942/2; CAEC-23) Avail: NTIS HC A05/MF A01 CSCL 08I

The Desert Hot Springs hydrothermal resource demonstrates its limited capacity to sustain additional utilization and development. The evaluation included the delineation of the areal extent, determination of the hydraulic characteristics, calculation of a safe yield, and identification of the source of heat. GRA

N79-25537# Northwestern Univ., Evanston, Ill. Center for Interdisciplinary Study of Science and Technology.

CONTEXTUAL ANALYSIS FOR INDUSTRIAL ENERGY CONSERVATION R AND D Final Report

Michael Radnor and Durward Hoffer Mar. 1978 355 p refs Sponsored by DOE

(Grant NSF PRA-76-SP-1311) (PB-290981/0; NSF/PRA-76-SP-1311-F) Avail: NTIS HC A16/MF A01 CSCL 10A

The potential usefulness of an analytical technique developed for use by policy makers in a wide variety of R&D and innovation-related situations and sectors was assessed. Operational procedures for identifying critical factors important to

program planning and project selection were developed. The technique is expected to be a useful supplement to conventional cost benefit analysis. GRA

N79-25538# Minnesota Energy Agency, St. Paul.

MINNESOTA COAL STUDY

Sep. 1978 137 p Sponsored in part by the Minnesota Dept. of Natural Resources, St. Paul, the Minnesota Dept. of Transportation, St. Paul, the Minnesota Pollution Control Agency, Roseville, and the Minnesota State Planning Agency, St. Paul (PB-292106/2; MEA/MCS-78) Avail: NTIS HC A07/MF A01 CSCL 10A

An analysis of several interrelated factors relative to consumption, transportation and handling, economic implications, and environmental impacts are studied. GRA

N79-25539# National Bureau of Standards, Washington, D. C. Center for Building Technology.

RESULTS AND ANALYSIS OF A ROUND-ROBIN TEST PROGRAM FOR LIQUID-HEATING FLAT-PLATE SOLAR COLLECTORS

E. R. Streed, W. C. Thomas (Virginia Polytechnic Inst. and State Univ., Blacksburg, Va.), A. G. Dawson, III (Virginia Polytechnic Inst. and State Univ., Blacksburg, Va.), B. D. Wood (Arizona State Univ.), and J. E. Hill Aug. 1978 122 p refs Sponsored in part by DOE

(PB-292115/3; NBS-TN-975) Avail: NTIS HC A06/MF A01 CSCL 10A

A round robin test program was conducted at 21 United States test facilities, using a common test procedure, to determine the intercomparability of thermal performance data pertaining to two liquid-heating flat-plate solar collectors. GRA

N79-25540# General Accounting Office, Washington, D. C. Energy and Mineral Div.

ANALYSIS OF THE ENERGY AND ECONOMIC EFFECTS OF IRANIAN OIL SHORTFALL

Mar. 1979 51 p (PB-292634/3; EMD-79-38) Avail: NTIS HC A04/MF A01 CSCL 10A

A partial listing of topic areas included the following: the size of the shortfall; international aspects; effects on the U. S. economy; government options. GRA

N79-25567# Lockheed Missiles and Space Co., Huntsville, Ala. Research and Engineering Center.

AIR POLLUTANT EMISSION FACTORS FOR MILITARY AND CIVIL AIRCRAFT Final Report, Aug. 1977 - Apr. 1978

D. Richard Sears Oct. 1978 91 p refs (Contract EPA-68-02-2614)

(PB-292520/4; LMSC-HREC-TR-D568208; EPA-450/3-78-117) Avail: NTIS HC A05/MF A01 CSCL 13B

Tables of military aircraft fuel characteristics, aircraft classifications, military and civil times in mode, engine modal emission rates, and aircraft emission factors per landing-takeoff cycle are calculated and compiled. The data encompass 59 engines and 89 aircraft. Information related to benzo(a)pyrene emissions and to hydrocarbon emissions (volatile organic) with potential to produce photochemical oxidant is discussed. GRA

N79-25570# Beck (R. W.) and Associates, Denver, Colo.

A PRIMER ON THE REJECTION OF WASTE HEAT FROM POWER PLANTS Final Report

Robert D. Mitchell and Randy D. Horsak May 1978 49 p (EPRI Proj. 927-1)

(PB-292529/5; CAEC-30) Avail: NTIS HC A03/MF A01 CSCL 13A

The workings and importance of cooling systems in power plants are described. Many of the terms used in the energy industry are defined. The cost and efficiency of various waste heat rejection systems (cooling systems), such as once-through circulating systems, cooling ponds and lakes, spray ponds, and wet and dry cooling towers are discussed. The effects of cooling systems on the environment, and on the production and cost of electricity, are considered. GRA

N79-25926# Committee of Conference (U. S. Congress).

ENERGY TAX ACT OF 1978

[1978] 33 p H.R. 5263 enacted into law by the 95th Congr., 9 Nov. 1978

(Pub-Law-95-618; GPO-39-139) Avail: US Capitol, House Document Room

The text of an Act of Congress to provide tax incentives for the production and conservation of energy and for other purposes is presented. Topics covered under the three titles of the Act are residential energy credit; gas guzzler tax; motor fuels; provisions related to buses; incentives for van pooling; and changes in business investment credit to encourage conservation of, or conversion from, oil and gas to encourage new energy technology. Miscellaneous provisions relate to the treatment of untangible drilling costs for the purposes of minimum tax; depletion of geothermal deposits and natural gas from geopressurized brine; and rerefined lubricating oil. A.R.H.

N79-25930# Army Mobility Equipment Research and Development Command, Fort Belvoir, Va.

BASLINE TESTS OF THE SEBRING CITI-VAN ELECTRIC DELIVERY TRUCK

Edward J. Dowgiallo, Jr., Cornelius E. Bailey, Jr., Ivan R. Snellings, and William H. Blake Feb. 1979 41 p refs
(Contract EC-77-A-31-1042)

(AD-A066582; MERADCOM-2268; DOE/CONS-0421-4) Avail: NTIS HC A03/MF A01 CSCL 13/6

The Citi-Van Model 611N0003, an electric two-passenger multipurpose van, was tested at the US Army Aberdeen Proving Ground test facilities in Aberdeen, Maryland, as part of a Department of Energy (DOE) project to characterize the state-of-the-art of electric vehicles. The Citi-Van is manufactured in Sebring, Florida, by Sebring Vanguard, Inc. It is powered by eight 6-volt batteries that are connected to the motor through a contactor control actuated by a foot pedal to control motor speed. The 6-horsepower motor drives the rear wheels through a direct drive to the differential. No regenerative braking was provided. Author (GRA)

N79-26121# California Univ., Livermore. Lawrence Livermore Lab.

PROTOTYPE DEVELOPMENT OF AN OPTIMIZED, TAPERED-THICKNESS, GRAPHITE/EPOXY COMPOSITE FLYWHEEL

S. V. Kulkarni, R. G. Stone, and R. H. Toland Nov. 1978 37 p refs

(Contract W-7405-eng-48)

(UCRL-52623) Avail: NTIS HC A03/MF A01

The design, fabrication, and testing of a prototype composite flywheel rotor are described and its potential as an efficient energy-storage device is assessed. The basic laminate layup for the composite flywheel was quasi-isotropic (0/+45/90), and the design was based on an ultimate strain failure criterion that stipulates simultaneous failure in the radial and hoop directions. The energy density of the flywheel rotor as obtained from the burst speed test was 28.4 W.h/lb (0.225 MJ/kg). Although this is a fairly high number, it still was lower than the predicted value of 54.8 W.h/lb (0.435 MJ/kg). Based on the laminate coupon data obtained from the scratch material machined out of the rotor as well as on those data obtained from panels supplied by the prepreg manufacturer, possible reasons for this lower-than-expected energy density are identified. Finally, recommendations are made for further development of the optimized rotor concept. DOE

N79-26143# Institute of Gas Technology, Chicago, Ill.

DEVELOPMENT OF COMBUSTION DATA TO UTILIZE LOW-Btu GASES AS INDUSTRIAL PROCESS FUELS Quarterly Status Report, 1 Apr. - 30 Jun. 1978

Richard T. Waibel and Edward S. Fleming Aug. 1978 31 p
(Contract EX-76-C-01-2489; Proj. 8985)

(FE-2489-30) Avail: NTIS HC A03/MF A01

Combustion trials were completed with the fourth burner (high forward momentum) and the fifth burner (flat-flame). Experiments have begun with the sixth burner (high-excess-air).

The high forward momentum burner could be operated with a stable flame using all three of the substitute fuel gases, Koppers-Totzek oxygen (KTO), Wellman-Galusha air (WGA) and Winkler air (WA). KTO performed slightly better than natural gas in terms of thermal efficiency while WGA and WA did not perform as well as natural gas. The flat-flame burner could not be operated with a flat-flame using any of the substitute fuels. Subsequent experiments found that modifying the air inlet and downrating the burner from 3 million Btu/hr to 2 million Btu/hr could achieve a flat-flame with KTO fuel gas. Much more serious downrating would be necessary for the low Btu Wellman-Galusha air and Winkler air fuel gases on this particular burner. DOE

N79-26146# Sandia Labs., Albuquerque, N. Mex. Laser Applications and Spectroscopy Div.

SANDIA LABORATORY COMBUSTION SIMULATION FACILITY

Kennith L. Goin Jan. 1979 28 p refs

(Contract EY-76-C-04-0789)

(SAND-78-2240) Avail: NTIS HC A03/MF A01

A test facility built to stimulate the flow of high temperature combustion products, including that through the channel of a coal fired MHD power generator, is described. The facility provides widely variable and closely controlled operating conditions for use in developing techniques for analyzing flows of combustion products. It also provides an environment for studies of materials and other technological problems related to coal fired MHD power plants. Some results of limited operational experience are included. DOE

N79-26147# Oak Ridge National Lab., Tenn.

CHARACTERIZATION OF MULTIALKYLATED POLYCYCLIC AROMATIC HYDROCARBONS IN ENERGY-RELATED MATERIALS

W. H. Griest, B. A. Tomkins, J. L. Epler, and T. K. Rao 1978 26 p refs Presented at 3d Symp. on Polynucl. Aromatic Hydrocarbons, Columbus, Ohio, Oct. 1978

(Contract W-7405-eng-26)

(CONF-781039-9) Avail: NTIS HC A03/MF A01

The composition and nature of multialkylated PAHs from a coal derived crude oil were studied to indicate that in some complex matrices, the multialkylated PAHs constitute a major portion of the PAH isolate. Their overall contribution to the mutagenicity of the PAH isolate appears to be substantial. The bioactive constituents of complex energy related materials should not overlook the potential importance of this class of PAHs. DOE

N79-26221*# General Electric Co., Evendale, Ohio.

EXPERIMENTAL CLEAN COMBUSTOR PROGRAM: DIESEL NO. 2 FUEL ADDENDUM, PHASE 3 Final Report

C. C. Gleason and D. W. Bahr May 1979 66 p refs

(Contract NAS3-19736)

(NASA-CR-135413; R79AEG367)

Avail: NTIS HC A04/MF A01 CSCL 21D

A CF6-50 engine equipped with an advanced, low emission, double annular combustor was operated 4.8 hours with No. 2 diesel fuel. Fourteen steady-state operating conditions ranging from idle to full power were investigated. Engine/combustor performance and exhaust emissions were obtained and compared to JF-5 fueled test results. With one exception, fuel effects were very small and in agreement with previously obtained combustor test rig results. At high power operating condition, the two fuels produced virtually the same peak metal temperatures and exhaust emission levels. At low power operating conditions, where only the pilot stage was fueled, smoke levels tended to be significantly higher with No. 2 diesel fuel. Additional development of this combustor concept is needed in the areas of exit temperature distribution, engine fuel control, and exhaust emission levels before it can be considered for production engine use. J.A.M.

N79-26222# Georgia Inst. of Tech., Atlanta. Engineering Experiment Station.

LABORATORY STUDY OF PYROLYSIS OF EXPLOSIVE CONTAMINATED WASTE Final Report

J. A. Knight, L. W. Elston, and R. Scola Feb. 1979 39 p refs
(Contract DAAK10-78-C-0153)
(AD-A066973; AD-E400292; ARLCD-CR-78027) Avail: NTIS
HC A03/MF A01 CSDL 13/2

Army ammunition plants dispose of large quantities of neat explosives and chemical and explosive contaminated waste by either open air burning or incineration. These disposal techniques do not take advantage of the potential fuel value (7000 BTU/lb (15.7 MJ/kg)) of these wastes. This laboratory study was conducted to investigate the feasibility of utilizing a pyrolytic process to convert explosive contaminated waste into a useable, storable fuel. The study consisted of a series of laboratory scale pyrolysis runs on explosive contaminated waste. The data points for the runs were 0, 0.5, 1, and 2% explosive contamination by weight. The results of the study indicate that AAP waste can be safely processed with no adverse environmental impact, to produce a storable fuel having a heat content of 14,000 BTU/lb (31.3 MJ/kg) with an energy conversion efficiency of approximately 70%. Author (GRA)

N79-26224# Air Force Aero Propulsion Lab., Wright-Patterson AFB, Ohio.

FUEL HYDROGEN CONTENT AS AN INDICATOR OF RADIATIVE HEAT TRANSFER IN AN AIRCRAFT GAS TURBINE COMBUSTOR Final Report, Jun. - Nov. 1976

Thomas A. Jackson and W. S. Blazowski Feb. 1979 24 p refs Presented at the Am. Soc. of Mech. Engr. Winter Ann. Meeting, Atlanta, 27 Nov. - 2 Dec. 1977
(AD-A067709; AFAPL-TR-79-2014) Avail: NTIS
HC A02/MF A01 CSDL 21/4

Eleven fuels representing a wide range of hydrogen content were studied using a T56 single can combustor rig. Test fuels included single and double ring aromatic types as well as paraffins blended with each other and with JP-4. Fuel mixtures with hydrogen contents ranging from 9.9 to 15.9 per cent by weight were examined. The combustor inlet conditions simulated the discharge from both low and high pressure ratio gas turbine compressors operating at the cruise condition. Thermocouple data from the T56 liner are correlated with fuel hydrogen content using a new, nondimensional combustor liner temperature parameter. Least-squares mathematical treatment of the data resulted in an excellent second order correlation between the nondimensional temperature parameter and fuel hydrogen content and a simplified radiation analysis is presented which also explains the resulting empirical trends. Author (GRA)

N79-26226# Fluor Engineers and Constructors, Inc., Irvine, Calif.
COAL LIQUEFACTION TEST CENTER Quarterly Technical Progress Report, Jan. - Mar. 1978

Sep. 1978 75 p
(Contract EX-76-C-01-1517)
(FE-1517-67) Avail: NTIS HC A04/MF A01

The attempt to bring the plant on stream in an integrated mode is described. DOE

N79-26228# Federal Energy Regulatory Commission, Washington, D. C. Technical Advisory Task Force.

NATIONAL GAS SURVEY: SYNTHESIZED GASEOUS HYDROCARBON FUELS

Jun. 1978 307 p refs
(DOE/FERC-0008) Avail: NTIS HC A14/MF A01

Coal hydrocarbon liquids, oil shales, tar sands, and bioconvertible materials were considered as potential feedstocks for gaseous fuels. Current status of process technology for each feedstock was reviewed, economic evaluations including sensitivity analysis were made, and constraints for establishment of a synthesized gaseous hydrocarbon fuels industry were considered. Process technology is presently available to manufacture gaseous hydrocarbon fuels from each of the feedstocks. In the economic evaluations presented, the most significant factor for liquid feedstock plants was the anticipated cost of feedstock and fuel. The economic viability of plants using other feedstocks was primarily dependent upon capital requirements. DOE

N79-26229# Public Service Electric and Gas Co., Newark, N. J.

BLENDING OF HYDROGEN IN NATURAL GAS DISTRIBUTION SYSTEMS. VOLUME 3: GAS BLENDS LEAKAGE TESTS OF SELECTED DISTRIBUTION SYSTEM COMPONENTS Final Report, 1 Jun. 1976 - 30 Apr. 1978

May 1978 66 p
(Contract EY-76-C-02-2925)
(CONS/2925-3) Avail: NTIS HC A04/MF A01

Twenty sample test joints, consisting of eleven cast-iron, cement, and jute joints, five steel joints, and four plastic joints, were tested using straight natural gas, varying blends of hydrogen with natural gas, and varying humidity levels of the gas mixture. Test results show: (1) cast-iron joints and steel joints that did not leak with natural gas did not leak with blends of up to 40% hydrogen in natural gas; (2) cast-iron joints and steel joints that had small leaks with natural gas did not leak at a higher rate with blends of up to 40% hydrogen in natural gas; (3) cast-iron joints that had large leaks with natural gas showed a detectable increase in leakage as the hydrogen level in the gas blend increased; (4) efforts to determine if the permeability of polyethylene tubing increases with increasing concentrations of hydrogen in natural gas, and with aging of the plastic, were inconclusive; and (5) there was no preferential leakage of hydrogen in any of the joints tested using blends with up to 40% hydrogen in natural gas. DOE

N79-26231# Oak Ridge National Lab., Tenn.

RELATIVE CHEMICAL COMPOSITION OF SELECTED SYNTHETIC CRUDES

W. H. Griest, M. R. Guerin, B. R. Clark, C. Ho, I. B. Rubin, and A. B. Jones 1978 21 p refs Presented at Symp. on Assessing the Ind. Hygiene Monitoring Needs for the Coal Conversion and Oil Shale Ind., Upton, N. Y., 5 Nov. 1978
(Contract W-7405-eng-26)

(CONF-781150-4) Avail: NTIS HC A02/MF A01

A knowledge of the composition of synthetic crudes can provide an important input into the assessment of occupation exposure monitoring requirements for the coal conversion and oil shale industries. Comparative compositional studies of coal and shale-derived crude oils with petroleum crude oils as a reference point are summarized. DOE

N79-26232# Institute of Gas Technology, Chicago, Ill.

PROCESS DESIGN FOR COAL CONVERSION REACTORS

W. W. Bodle, A. T. Talwalkar, and D. V. Punwani 12 Nov. 1978 24 p refs Presented at 71st AIChE Natl. Meeting, Miami, Fla., 12-16 Nov. 1978
(Contract EX-76-C-01-2286)

(CONF-781110-15) Avail: NTIS HC A02/MF A01

There are many cases where general design procedures developed for other industries cannot be applied to coal conversion systems until after suitable modifications were made to account for (1) differences in types of materials handled, or (2) differences in processing conditions. For example, in the petroleum industry, design criteria were developed for designing fluidized-bed catalytic cracking units. These design criteria are not generally applicable to coal conversion systems because cracking catalyst has unique properties (ultrafine particles of low density), and because higher temperatures and pressures may be employed in coal conversion systems. It is the purpose to call attention to some of the design data and procedures included in the Coal Data Book and to illustrate their use by application to the design of a particular hypothetical reactor system for converting coal to fuel gas and oil. DOE

N79-26233# California Univ., Davis.

THE PRODUCTION OF ETHANOL FROM AGRICULTURAL WASTE: AN ECONOMIC EVALUATION Final Report

David Paige and Roger Boulton Jan. 1979 31 p refs Sponsored by Calif. Energy Commission
(PB-292552/7; CAEC-28) Avail: NTIS HC A03/MF A01 CSDL 21D

The quantities of wet waste and dry waste available in California are estimated. Economic analyses based on investment rate of return are developed for four alternate process schemes.

varying in complexity from a simple pretreatment, fermentation, and distillation process to a process involving pretreatment, enzymatic hydrolysis, concentration, aerobic ethanol fermentation, and distillation. The hypothesized schemes use tomato and peach cannery wastes and/or rice straw as feedstocks. The economic sensitivity to plant size, ethanol market price, and waste treatment credit is shown. Annual investment rates of return of from 7 to 12 percent are calculated. GRA

N79-26234# Battelle Columbus Labs., Ohio.

FUEL CONTAMINANTS. VOLUME 3: CONTROL OF COAL-RELATED POLLUTANTS Final Report, Jul. 1975 - 1976

E. J. Mezey, Seongwoo Min, B. R. Allen, W. C. Baytos, and Surjit Singh Jan. 1979 135 p refs
(Contract EPA-68-02-2112)

(PB-293328/1; EPA-600/7-79-025A) Avail: NTIS HC A07/MF A01 CSCL 21D

The results of a study to identify strategies for removing pollutants from coal and coal derived liquids are reported. Study findings include: (1) enhancement of pyrite removal during immiscible fluid agglomeration--removal equivalent to that obtained for float-sink analysis was obtained by pretreatment and oil agglomeration, (2) extraction of clean fuels from coal liquids--light hydrocarbons can be used to extract 83% of coal liquid at supercritical conditions to yield a low sulfur and nitrogen fuel; (3) concentration of organic sulfur and nitrogen and ash from coal liquids--up to 76% of the sulfur and about 10% of the nitrogen can be removed by passing coal liquids over various special porous media; and (4) conversion of coal liquefaction residues to environmentally acceptable fuels. GRA

N79-26235# Lockman and Associates, Monterey Park, Calif.
RECOVERY, PROCESSING, AND UTILIZATION OF GAS FROM SANITARY LANDFILLS Final Report, Mar. 1977 - Sep. 1978

Robert K. Ham, Kenneth K. Hekimian, Stanley L. Katten, Wilbur J. Lockman, and Ronald J. Lofy Feb. 1979 147 p refs
(Contract EPA-68-03-2536)

(PB-293165/7; EPA-600/2-79-001) Avail: NTIS HC A07/MF A01 CSCL 21D

Topics covered include: The three-component gas generation phenomenon; analysis and comparison of alternative gas utilizations including the processes necessary to prepare the gas for use; an evaluation of various landfill design approaches and operations techniques that show promise for enhancing gas generation, recovery efficiency and quality; and recommendations for research, development and demonstration projects deemed necessary to develop an adequate data base to proceed with more in depth engineering evaluations of the various options. Overall, it is shown that landfill gas recovery, processing and utilization is technically feasible and can be economically viable. GRA

N79-26236# Battelle Columbus Labs., Ohio.

FUEL CONTAMINANTS, VOLUME 4: APPLICATION OF OIL AGGLOMERATION TO COAL WASTES Final Report, Aug. 1977 - Apr. 1978

E. J. Mezey, Seongwoo Min, and Dale Folsom Jan. 1979 95 p refs

(Contract EPA-68-02-2112)
(PB-293210/1; EPA-600/7-79-025B-Vol-4) Avail: NTIS HC A05/MF A01 CSCL 081

Several approaches to enhance pyrite removal during agglomeration and to demonstrate the utility of the technology to reduce the environmental impact of increased quantities of coal cleaning refuse were investigated. Results show that the coal recovered is of better quality than the coal now being shipped from the mine, in that sulfur and ash values are lower. Coal value recoveries were greater than 90%. GRA

N79-26237# General Electric Co., Santa Barbara, Calif. Center for Advanced Studies.

COMPENDIUM REPORTS ON OIL SHALE TECHNOLOGY
G. C. Slawson, Jr. and T. F. Yen Jan. 1979 224 p
(Contract EPA-68-03-2449)

(PB-293279/6; GE77TMP-52; EPA-600/7-79-039) Avail: NTIS HC A10/MF A01 CSCL 081

The various production processes (mining, retorting, and oil upgrading) and key environmental factors (organic and inorganic characterization, environmental control, and limitations) related to oil shale development are discussed. This state-of-the-art survey supports a study designing a groundwater quality monitoring program for oil shale operations such as that proposed for Federal Oil Shale Lease Tracts U-a and U-b located in northeastern Utah. Technologies applicable to this development are emphasized while a general overview of oil shale technology is given. GRA

N79-26240# Electricite de France, Chatou. Div. Etudes Generales and Methodes.

COMPARISON OF DIFFERENT TECHNIQUES FOR PRODUCING HYDROGEN: PRODUCTION COSTS ANALYSIS [COMPARISON DES PROCEDES DE PRODUCTION D'HYDROGENE - ELEMENTS D'APPRECIATION DES COUTES DE PRODUCTION]

J. Y. Portas Dec. 1976 79 p refs In FRENCH

(P/51/76/14) Avail: NTIS HC A05/MF A01

A multivariable economic analysis of different techniques available, or under study, for the production of hydrogen as an alternative energy source is given. Present and projected costs of hydrogen production by electrolysis are considered. Alternative techniques such as vapor reconstitution or partial oxidation of hydrocarbons, coal gasification, and thermochemistry are also evaluated. Finally, an in depth cost analysis of methods for obtaining hydrogen by electrolysis is made in order to provide a basis for comparison with other techniques. Author (ESA)

N79-26384*# Mathematical Sciences Northwest, Inc., Bellevue, Wash.

DESIGN INVESTIGATION OF SOLAR POWERED LASERS FOR SPACE APPLICATIONS Final Report

R. Taussig, C. Bruzzone, D. Quimby, L. Nelson, W. Christiansen, S. Neice, P. Cassidy, and A. Pindroh May 1979 184 p refs
(Contract NAS3-21134)

(NASA-CR-159554; MSNW-79-1087/1090-1) Avail: NTIS HC A09/MF A01 CSCL 20E

The feasibility of solar powered lasers for continuous operation in space power transmission was investigated. Laser power transmission in space over distances of 10 to 100 thousand kilometers appears possible. A variety of lasers was considered, including solar-powered GDLs and EDLs, and solar-pumped lasers. An indirect solar-pumped laser was investigated which uses a solar-heated black body cavity to pump the lasant. Efficiencies in the range of 10 to 20 percent are projected for these indirect optically pumped lasers. G.Y.

N79-26408# Central Electricity Generating Board, Harrogate (England). Mechanical Engineering Branch.

PULVERISED FUEL NON-RETURN FLAP VALVE

P. Holdsworth Dec. 1978 3 p Original contains color illustrations

(TDB-317) Avail: NTIS HC A02/MF A01

All previous nonreturn flap valves for P.F. pipelines have been fabricated or cast with bodies of rectangular section. These are inherently weak when subject to an internal pressure. As some P.F. systems now have to withstand an internal pressure of 31 bars, the logical shape to make the body is tubular, but this then created a design problem with the flap. This has been overcome by making the flap curved so that in the open position it will fit closely against the side of the body. The shape of the seat also tends to avoid build-up of dormant P.F. deposits. Color illustrations of a prototype are given. Author (ESA)

N79-26410# Environmental Protection Agency, Ann Arbor, Mich. Standards Development and Support Branch.

EXHAUST EMISSIONS AND FUEL CONSUMPTION OF A HEAVY-DUTY GASOLINE POWERED VEHICLE OVER VARIOUS DRIVING CYCLES: 427 CUBIC INCH 1977 CALIFORNIA GMC 6500

Richard Nash Aug. 1978 42 p

(PB-293530/2; HDV-78-09) Avail: NTIS HC A03/MF A01 CSCL 21D

The driving cycles were developed from actual in-use operational data collected in New York and Los Angeles. In each location, both freeway and non-freeway operational parameters were recorded. A data matrix (relating speed, acceleration and frequency of occurrence) was prepared for each city and class of operation. Evaluation of the concept of chassis testing for heavy-duty vehicles was the major purpose of this project. The test program was designed to measure the sensitivity of exhaust emissions and fuel economy to the various driving cycles and road load conditions. GRA

N79-26411# Department of Energy, Bartlesville, Okla. Energy Research Center.

PERFORMANCE CHARACTERISTICS OF AUTOMOTIVE ENGINES IN THE UNITED STATES. THIRD SERIES: REPORT NO. 2, 1978 PONTIAC, 301 CID (4.9 LITERS), 2V Interim Report

D. E. Koehler and M. F. Marshall May 1978 59 p
(Contract DOT-TSC-RA-77-07)
(PB-293772/0; BERC/OP-78/21; DOT-TSC-NHTSA-79-2; DOT-HS-803-831) Avail: NTIS HC A04/MF A01 CSCL 21G

Experimental data were obtained in dynamometer tests to determine fuel consumption and emissions (hydrocarbon, carbon monoxide, oxides of nitrogen) at steady-state engine operating modes. The engine performance data obtained are used to estimate and emissions and fuel economy for varied engine service and duty to provide basic input for engineering calculations involving transportation. GRA

N79-26412# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. **AUTOMOTIVE FUEL ECONOMY AND EMISSIONS EXPERIMENTAL DATA Final Report, Jun. 1975 - Dec. 1976**

Mack W. Dowdy and Ronald L. Baisley Feb. 1979 217 p refs
(Contract DOT-TSC-RA-75-41)
(PB-293580/7; JPL-Pub-78-21; DOT-HS-803-808; DOT-TSC-NHTSA-19-15) Avail: NTIS HC A10/MF A01 CSCL 13F

An assessment of the relationship between automobile fuel economy and emission control systems is given. Tests were made at both the engine and vehicle levels. Investigations were made on cold-start emissions devices, exhaust gas recirculation systems, and air injection reactor systems. An alternative emission control system and modified control strategy were implemented and tested in the vehicle based on the results of engine tests. With the same fuel economy and NOx emissions as the stock vehicle, the modified vehicle reduced HC and CO emissions by about 20 percent. By removing the NOx emissions constraint, the modified vehicle demonstrated about 12 percent better fuel economy than the stock vehicle. GRA

N79-26472 Maryland Univ., College Park. **ANALYSIS OF FLAT MIRROR V-TROUGH SOLAR CONCENTRATOR Ph.D. Thesis**

Byung Chan Son 1978 263 p
Avail: Univ. Microfilms Order No. 7913704

A study of solar concentrators which utilize mirrored slats focusing onto a central receiver tube by rotation about their center lines is presented. The flat mirror slats are placed in an array whose center line lies in two planes forming a V-trough. An extensive optical analysis was made on flat mirror surfaces, using a Gaussian reflection model. The factors considered in the analysis include the distance between the mirror surface and the image plane, the solar cone angle and the surface irregularities. Based on the results of the optical analysis, a computer program was written to determine the rate of solar energy reflected from the mirror surface and reaching the receiver tube under the computer simulated weather data. The design configurations considered are the slope angle of the V-trough, the height of the receiver tube, the design sun angle, the mirror width, the size of the receiver tube, the tilt adjustments per year, the flatness of mirror surface, the yearly average concentration ratio and the geographical locations. Dissert. Abstr.

N79-26473 Stanford Univ., Calif.

PREPARATION AND PROPERTIES OF Au-(I-N) A SUB X Ga SUB 1 MINUS X As-(n)GaAs SCHOTTKY-BARRIER SOLAR CELLS Ph.D. Thesis

Yie-Der Shen 1979 87 p
Avail: Univ. Microfilms Order No. 7912410

Energy band diagrams of GaAs Schottky-barrier solar cells were derived. The results indicate that, because of the properties of heterojunctions, a barrier to holes appears in the valence band at the junction when the thickness of the AlGaAs layer is near to or larger than the Schottky-barrier depletion width. The presence of this barrier degrades collection efficiency. Calculations, however, revealed that this barrier disappears when the thickness of the AlGaAs layer is less than 1000 Å and the carrier concentrations in the layers were correctly chosen. This result was confirmed by spectral response measurements. A horizontal slider liquid phase epitaxial growth system was then developed for growing high quality AlGaAs-GaAs double layers with an AlGaAs layer thickness of 150 to 500 Å. Dissert. Abstr.

N79-26475* National Aeronautics and Space Administration. Marshall Space Flight Center, Huntsville, Ala.

METHOD OF CONSTRUCTION OF A MULTI-CELL SOLAR ARRAY Patent

Donald E. Routh, Ben R. Hollis, and William R. Feltner, inventors (to NASA) Issued 29 May 1979 4 p Filed 23 Dec. 1977 Supersedes N78-17468 (16 - 08 p 1036)
(NASA-Case-MFS-23540-1; US-Patent-4,156,309; US-Patent-Appl-SN-863773; US-Patent-Class-29-572; US-Patent-Class-29-577; US-Patent-Class-29-578; US-Patent-Class-29-580; US-Patent-Class-357-45) Avail: US Patent and Trademark Office CSCL 10A

The method of constructing a high voltage, low power, multicell solar array is described. A solar cell base region is formed in a substrate such as but not limited to silicon or sapphire. A protective coating is applied on the base and a patterned etching of the coating and base forms discrete base regions. A semiconductive junction and upper active region are formed in each base region, and defined by photolithography. Thus, discrete cells which are interconnected by metallic electrodes are formed. Official Gazette of the U.S. Patent and Trademark Office

N79-26476*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

HANDBOOK OF DATA ON SELECTED ENGINE COMPONENTS FOR SOLAR THERMAL APPLICATIONS

Jun. 1979 240 p refs Prepared for DOE
(Contract EX-76-A-29-1060)
(NASA-TM-79027; E-9822; DOE/NASA/1060-78/1) Avail: NTIS HC A11/MF A01 CSCL 10B

A data base on developed and commercially available power conversion system components for Rankine and Brayton cycle engines, which have potential application to solar thermal power-generating systems is presented. The status of the Stirling engine is discussed.

N79-26477*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

SOLAR THERMAL POWER-CONVERSION SYSTEM

Harvey S. Bloomfield In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979 p 3-12
Avail: NTIS HC A11/MF A01 CSCL 10B

The structure, applications, and operating concepts of solar thermal power conversion system are described. S.E.S.

N79-26478*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RANKINE-CYCLE COMPONENT CHARACTERISTICS

Thaddeus S. Mroz and M. Murray Bailey In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl. Jun. 1979 p 13-83
Avail: NTIS HC A11/MF A01 CSCL 10B

The performance and cost data for the major components of steam and organic Rankine cycle power conversion systems

N79-26479

are presented. Rankine cycle components discussed include: (1) steam and organic turbines; (2) reciprocating engines; (3) surface condensers; and (4) boiler feed and condensate pumps. Component designs, component development status, operating characteristics, availability, cost, and component experience factors are described. S.E.S.

N79-26479*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

BRAYTON-CYCLE COMPONENT CHARACTERISTICS

Thaddeus S. Mroz, Jack A. Heller, and Harvey S. Bloomfield *In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl.* Jun. 1979 p 85-126

Avail: NTIS HC A11/MF A01 CSCL 10B

The gas turbine engine which operates on the Brayton cycle principle is described. The two basic types of Brayton gas turbine engine were developed and are presented in use: the closed cycle engine and open cycle engine. S.E.S.

N79-26480*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

STIRLING ENGINE CHARACTERISTICS

Harry M. Cameron *In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl.* Jun. 1979 p 127-157

Avail: NTIS HC A11/MF A01 CSCL 10B

The Stirling engine is described for the following factors: (1) excellent fuel economy; (2) low exhaust emissions; (3) multifuel capability; (4) flat torque curve; and (5) low noise level. The Stirling cycle, free piston engines, and the seals and hydrogen containment are discussed. S.E.S.

N79-26482*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

COMMERCIAL SYNCHRONOUS ALTERNATING-CURRENT GENERATORS

James H. Dunn *In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl.* Jun. 1979 p 175-186

Avail: NTIS HC A11/MF A01 CSCL 10B

Different types of generator and generator system are discussed. Variable speed and constant frequency systems are described. The flux switch alternator in alternating current generators used for induction hardening was examined for industrial utilization. S.E.S.

N79-26483*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

POWER-CONVERSION SYSTEM COMPONENT SUMMATION

Thaddeus S. Mroz, M. Murray Bailey, Jack A. Haller, Harvey S. Bloomfield, Robert J. Stochl, and Robert E. Hyland *In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl.* Jun. 1979 p 187-190

Avail: NTIS HC A11/MF A01 CSCL 10B

Commercial components applicable to Rankine cycle, Brayton cycle, and Stirling cycle solar thermal power generating systems were surveyed. The solar thermal power generating systems and their components are described. Data on these components are presented and include development status, availability, cost, operating constraints, operating characteristics, and experience factors. S.E.S.

N79-26484*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

CANDIDATE POWER-CONVERSION SYSTEM CYCLES, APPENDIX A

Robert J. Stochl *In its Handbook of Data on Selected Eng. Components for Solar Thermal Appl.* Jun. 1979 p 191-209

Avail: NTIS HC A11/MF A01 CSCL 10B

The Rankine cycle, Brayton cycle, and Stirling cycle are described for solar thermal applications. The basic cycle configuration, its operation, and the basic relations for calculating cycle efficiencies and work outputs are presented. The system modifications used to increase performance over that of the basic cycle are discussed. S.E.S.

N79-26485*# Pennsylvania Univ., Philadelphia. Moore School of Electrical Engineering.

ANALYSIS AND EVALUATION OF PROCESSES AND EQUIPMENT IN TASKS 2 AND 4 OF THE LOW-COST SOLAR ARRAY PROJECT Quarterly Report, Apr. - Jul. 1978

H. Goldman and M. Wolf Nov. 1978 220 p refs Sponsored by NASA Prepared for DOE and JPL

(Contract JPL-954796)

(NASA-CR-158744; DOE/JPL-954796-78/4) Avail: NTIS HC A10/MF A01 CSCL 10A

The significant economic data for the current production multiblade wafering and inner diameter slicing processes were tabulated and compared to data on the experimental and projected multiblade slurry, STC ID diamond coated blade, multiwire slurry and crystal systems fixed abrasive multiwire slicing methods. Cost calculations were performed for current production processes and for 1982 and 1986 projected wafering techniques. Author

N79-26486*# Optical Coating Lab., Inc., City of Industry, Calif. Photoelectronics Div.

SILICON SOLAR CELL PROCESS DEVELOPMENT, FABRICATION AND ANALYSIS Quarterly Report, 1 Jan. - 31 Mar. 1979

H. I. Yoo, P. A. Iles, and D. P. Tanner 31 Mar. 1979 73 p refs Prepared for DOE and JPL

(Contract JPL-955089)

(NASA-CR-158736; DOE/JPL-955089-79/4; QR-3) Avail: NTIS HC A04/MF A01 CSCL 10A

The standard solar cells (2x2 cm) from the cast silicon (HEM) showed a maximum AMO efficiency of 10.1%. Cells from the low resistivity material (0.5 ohm-cm) showed lower performance than those of the high resistivity cast silicon (3 ohm-cm), an average efficiency 9.5% versus 7.6%. Maximum AMO efficiency of the standard solar cells from the EFG (RH) ribbons was about 7.5%. The solar cells from the controlled SiC, using the displaced die, showed more consistent and better performance than those of the uncontrolled SiC ribbons, an average efficiency of 6.6% versus 5.4%. The average AMO efficiency of the standard SOC solar cells were about 6%. These were large area solar cells (an average area of 15 sq cm). A maximum efficiency of 7.3% was obtained. The SOC solar cells showed both leakage and series resistance problems, leading to an average curve fill factor of about 60%. Author

N79-26490*# Spectrolab, Inc., Sylmar, Calif.

SILICON SOLAR CELL PROCESS DEVELOPMENT, FABRICATION AND ANALYSIS Quarterly Report, Jan. - Mar. 1979

Joseph A. Minahan Mar. 1979 54 p Sponsored by NASA Prepared for DOE and JPL

(Contract JPL-955055)

(NASA-CR-158740; DOE/JPL-955055-78/1; QR-2) Avail: NTIS HC A04/MF A01 CSCL 10A

Solar cells were constructed from polycrystalline silicon sheet material (10 cm x 10 cm). These cells were made using conventional aerospace methods and serve as the so-called baseline cell for analysis and comparison with cells to be made from similar material, but using optimized processing techniques. Before and during the processing of the baseline cells in a cleaned diffusion tube, control cells were built using the baseline method. All cells were measured on a solar simulator at air mass zero and 28 C. Average efficiency for the baseline cells was 9.5%. Efficiency was found to vary with location in the sheet. Center regions had higher efficiencies whereas corner and edge regions had lower efficiencies. In general, the efficiency falls off with distance from the center of the sheet. Author

N79-26491*# Barry (Theodore) and Associates, Los Angeles, Calif.

SAMICS VALIDATION. SAMICS SUPPORT STUDY. PHASE 3 Final Report

Mar. 1979 145 p refs Prepared for DOE and JPL (Contracts NAS7-100; JPL-955123) (NASA-CR-158746; DOE/JPL-955123-79/1; JPL-9950-100) Avail: NTIS HC A07/MF A01 CSCL 10A

SAMICS provides a consistent basis for estimating array costs and compares production technology costs. A review and a validation of the SAMICS model are reported. The review had the following purposes: (1) to test the computational validity of the computer model by comparison with preliminary hand calculations based on conventional cost estimating techniques; (2) to review and improve the accuracy of the cost relationships being used by the model; and (3) to provide an independent verification to users of the model's value in decision making for allocation of research and development funds and for investment in manufacturing capacity. It is concluded that the SAMICS model is a flexible, accurate, and useful tool for managerial decision making. G.Y.

N79-26495*# Optical Coating Lab., Inc., City of Industry, Calif. Photoelectronics Div.

SILICON SOLAR CELL PROCESS DEVELOPMENT, FABRICATION AND ANALYSIS Quarterly Report, 1 Jan. - 31 Mar. 1979

H. I. Yoo, P. A. Iles, and D. P. Tanner 31 Mar. 1979 74 p refs Prepared for DOE and JPL (Contract JPL-955089) (NASA-CR-158735; DOE/JPL-955089-79/3; QR-3) Avail: NTIS HC A04/MF A01 CSCL 10A

The standard solar cells (2x2 cm) from the cast silicon heatexchanger method) showed a maximum AMO efficiency of 10.1%. Cells from low resistivity material (0.5 ohm-cm) showed lower performance than those of the high resistivity cast silicon (3 ohm-cm), an average efficiency 9.5% versus 7.6% Maximum AMO efficiency of the standard solar cells (2x2 cm) from the EFG (RH) ribbons was about 7.5%. The solar cells from controlled SiC, using the displaced die, showed more consistent and better performance than those of the uncontrolled SiC ribbons, an average efficiency of 6.6% versus 5.4% The average AMO efficiency of the standard silicon ceramic (soc) solar calls were about 6%. These were large area solar cells (an average area of 15 sq cm). A maximum efficiency of 7.3% was obtained. The SOC solar cells showed both leakage and series resistance problems, leading to an average curve fill factor of about 60%.

Author

N79-26498*# Spectrolab, Inc., Sylmar, Calif.

ARRAY AUTOMATED ASSEMBLY, PHASE 2 Quarterly Report for 31 Mar. 1979

William E. Taylor, N. Mardesich, B. Edwards, S. Bunyan, and A. Garcia May 1979 36 p Sponsored by NASA Prepared for DOE and JPL (Contract JPL-954853) (NASA-CR-158728; DOE/JPL-954853-79/2) Avail: NTIS HC A03/MF A01 CSCL 10A

The baseline process sequence using nontextured square wafers was integrated. Difficulties encountered include: (1) replacement of the N-250 spray on diffusion source with PX-10 source; and (2) modification of the firing for printed silver and aluminum contracts is required to accommodate the change of wafer size and shape. Results indicate that the cells processed through the entire process sequence except laser scribe and spray on AR coating indicate the process sequence is feasible. Greater cell conversion efficiency is presented. S.E.S.

N79-26499*# Westinghouse Electric Corp., Trafford, Pa. Power Circuit Breaker Div.

DEVELOPMENT OF A PROCESS FOR A HIGH CAPACITY ARC HEATER PRODUCTION OF SILICON FOR SOLAR ARRAYS Quarterly Technical Report, Oct. 1978 - Feb. 1979

William H. Reed 1979 99 p refs Prepared for JPL and DOE

(Contract JPL-954589)

(NASA-CR-158745; DOE/JPL-954589-78/8; JPL-9950-112) Avail: NTIS HC A05/MF A01 CSCL 10A

A program was established to develop a high temperature silicon production process using existing electric arc heater technology. Silicon tetrachloride and a reductant (sodium) are injected into an arc heated mixture of hydrogen and argon. Under these high temperature conditions, a very rapid reaction is expected to occur and proceed essentially to completion, yielding silicon and gaseous sodium chloride. Techniques for high temperature separation and collection were developed. Included in this report are: test system preparation; testing; injection techniques; kinetics; reaction demonstration; conclusions; and the project status. G.Y.

N79-26502*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

THE USE OF WIND DATA WITH AN OPERATIONAL WIND TURBINE IN A RESEARCH AND DEVELOPMENT ENVIRONMENT

Harold E. Neustadter 1979 13 p refs Presented at the Am. Meteorological Soc., Portland, Oreg., 19-21 Jun. 1979 (Contract E(49-26)-1004)

(NASA-TM-73832; DOE/NASA/1004-79/16; E-9419) Avail: NTIS HC A02/MF A01 CSCL 10A

The status of the use of wind information is presented in four areas, namely: operational control, design verification, power performance analysis, and lifetime estimation. Attention is given to some of the identified wind information needs and the steps taken to meet these needs. M.M.M.

N79-26503*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

A METHOD FOR CORRELATING PERFORMANCE DATA OF A TERRESTRIAL SOLAR CELL ARRAY

Frederick F. Simon May 1979 45 p refs Prepared for DOE (NASA-TM-79163; DOE/NASA/20485-79/2; E-023) Avail: NTIS HC A03/MF A01 CSCL 10A

An analytical method was proposed for characterizing array power output, in the region of maximum power, as a function of environmental variables. The correlation provided a way of evaluating the output of an array under environmental conditions that differ from those encountered during testing. Power data obtained at one location was used to predict array performance at other locations. R.E.S.

N79-26504*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

LARGE HORIZONTAL AXIS WIND TURBINE DEVELOPMENT

William H. Robbins and Ronald L. Thomas 1979 16 p refs Presented at the Wind Energy Innovative Systems Conf., Colo. Springs, Colo., 23-25 May 1979; sponsored by Solar Energy Res. Inst.

(Contract E(49-26)-1059) (NASA-TM-79174; DOE/NASA/1059-79/2; E-039) Avail: NTIS HC A02/MF A01 CSCL 10A

An overview of the NASA activities concerning ongoing wind systems oriented toward utility application is presented. First-generation-technology large wind turbines were designed and are in operation at selected utility sites. In order to make a significant energy impact, costs of 2 to 3 cents per kilowatt hour must be achieved. The federal program continues to fund the development by industry of wind turbines which can meet the cost goals of 2 to 3 cents per kilowatt hour. Lower costs are achieved through the incorporation of new technology and innovative system design to reduce weight and increase energy capture. M.M.M.

N79-26505*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

RECENT ADVANCES IN REDOX FLOW CELL STORAGE SYSTEMS

Lawrence H. Thaller 1979 10 p refs Presented at the 14th Intersoc. Energy Conversion Eng. Conf., Boston, 5-10 Aug. 1979 Prepared for DOE

(Contract EC-77-A-31-1002)
(NASA-TM-79186; DOE/NASA/1002-79/4; E-053) Avail:
NTIS HC A02/MF A01 CSCL 10C

Several features which were conceived and incorporated into complete redox systems that greatly enhanced its ability to be kept in proper charge balance, to be capable of internal voltage regulation, and in general be treated as a true multicell electrochemical system rather than an assembly of single cells that were wired together, were discussed. The technology status as it relates to the two application areas of solar photovoltaic/wind and distributed energy storage for electric utility applications was addressed. The cost and life advantages of redox systems were also covered. R.E.S.

N79-26507# Committee on Energy and Natural Resources (U. S. Senate).

EXECUTIVE ENERGY DOCUMENTS.

Washington GPO 1978 433 p refs Documents for Comm. on Energy and Natural Resources, 95th Congr., 2d Sess., Jul. 1978

(GPO-24-112; Publ-95-114) Avail: SOD HC

The Presidential speeches and messages from over the past eight years which document the evolution of the United States energy policy are presented. The first energy policy statements stressed the development of domestic energy sources, especially nuclear energy. Subsequent messages continued the theme of developing domestic energy resources while proposing various measures to reduce U. S. dependence on oil imports. The recent Presidential statements have stressed energy conservation. R.E.S.

N79-26508# Committee on Energy and Natural Resources (U. S. Senate).

ENERGY: FISCAL YEAR 1980 BUDGET REQUEST

Washington GPO 1979 257 p refs Hearing before the Comm. on Energy and Natural Resources, 96th Congr., 1st Sess., 7 Feb. 1979

(GPO-42-886; Publ-96-9) Avail: Comm. on Energy and Natural Resources

The proposed energy budget for the coming fiscal year was examined. The principle issue examined was whether or not the proposed budget reflected the urgency needed to solve the United States' energy problems; that is, if enough money going into the research and development ideas which will benefit the country best. R.E.S.

N79-26509# Committee on Energy and Natural Resources (U. S. Senate).

THE NATIONAL ENERGY ACT

Washington GPO 1979 601 p refs Rept. for Comm. on Energy and Natural Resources, 96th Congr., 1st Sess., Jan. 1979

(GPO-36-956; Publ-96-1) Avail: SOD HC

Highlights are presented of each of the five acts which makeup NEA: conservation, coal conversion, utility rate reform, natural gas, and tax credits. Import savings are discussed, and detailed fact sheets on the five acts are included. F.O.S.

N79-26510# SRI International Corp., Menlo Park, Calif.

A PILOT STUDY OF THE POTENTIAL FOR NAVY UTILIZATION OF SOLID WASTE DERIVED FUELS TO OFFSET FOSSIL FUELS CONSUMPTION Final Report

Arlie G. Capps, Marilyn Duffey-Armstrong, and Robert E. Freeman Jun. 1978 38 p refs

(Contract N00014-76-C-0351)

(AD-A067165) Avail: NTIS HC A03/MF A01 CSCL 13/2

A brief study was made to define problems that would be encountered in estimating potential Navy markets for various forms of waste derived fuels. Fossil fuel consumption estimates for boiler plants at several Navy activities were converted to waste derived fuel (WDF) estimates using a set of assumed rules judged technically feasible regarding boiler conversions and confirming of Fossil Fuels and WDF. The results of this first study are presented indicating Navy boilers might represent a significant market for all the WDF. A region could produce if the WDF were available in liquid as well as solid forms. The economic feasibility of conversions and WDF production are not addressed in this brief paper. Author (GRA)

N79-26511# Wisconsin Univ. - Madison. Dept. of Nuclear Engineering.

PROPOSAL TO THE UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION FOR CONTINUATION OF FUSION REACTOR TECHNOLOGY STUDIES Progress Report, 1 Oct. 1977 - 1 Jul. 1978

R. W. Conn, G. L. Kulcinski, and C. W. Maynard 1978 47 p refs

(Contract ET-78-S-02-4636)

(COO-4636-1) Avail: NTIS HC A03/MF A01

Since the last progress report, concentration was on three main areas of research: (1) the study of the NUWMAK reactor design; (2) the study of rf heating for Tokamak reactors, and (3) the initiation of a tandem mirror reactor study. The initial work on the tandem mirror reactor is included as background in the technical proposal. Summaries of the work on recent assessments of lithium reserves and neutral transport codes are included. DOE

N79-26512# Sandia Labs., Albuquerque, N. Mex.

VERTICAL AXIS WIND TURBINE STATUS

C. H. Braasch and G. E. Brandvold 1978 12 p refs Presented at the Intern. Solar Energy Congr., New Delhi, 16 Jan. 1978 (Contract EY-76-C-04-0789)

(SAND-78-0397C; Conf-780114-4)

Avail: NTIS

HC A02/MF A01

Research and development activities on the Darriens wind turbine at Sandia Laboratories are described. DOE

N79-26513# McDonnell-Douglas Astronautics Co., Huntington Beach, Calif.

CENTRAL RECEIVER THERMAL POWER SYSTEM

Raymon W. Hallet, Jr. and Robert L. Gervais 1978 18 p Presented at Symp. on Solar Thermal Power Stations, Cologne, 11 Apr. 1978

(AED-Conf-78-212-008; Conf-7804108-4) Avail: NTIS (US Sales Only) HC A02/MF A01; DOE Depository Libraries

An overview is presented of a central receiver solar thermal electric system presently being developed. The design is distinct in that it used: (1) centrally supported, low-cost heliostats; (2) an external single pass-to-superheat receiver; and (3) a sensible heat, thermocline-type thermal storage. In its commercial version, the system is capable of producing 100 MWe and is designed to accommodate peak to intermediate plant operational modes. The principal working medium is water-steam. The system is designed for a 30-year operational life with a 90% plant availability goal. The definition of a 10-MWe Pilot Plant is also presented. DOE

N79-26514# California Univ., Livermore. Lawrence Livermore Lab.

LLL WIND ENERGY STUDIES (OAHU)

Joseph B. Knox Jan. 1979 21 p refs Presented at Wind Energy, Here and Now Symp., Honolulu, Hawaii, 19 Dec. 1978 (Contract W-7405-eng-48)

(UCRL-82171; Conf-781239) Avail: NTIS HC A02/MF A01

The role in the National Wind Energy Program assigned to LLL is the development and verification of a site screening methodology for wind energy resources. The site screening methodology and the Oahu studies of the past three years include: (1) 3-dimensional diagnostic flow simulation over complex terrain, (2) modern statistical techniques of pattern recognition adapted to regional wind fields, and (3) remote sensing of atmospheric wind field by laser scintillation. The LLL team is to provide the DOE with a suitable site screening methodology for wind energy, and a significant data base of two years duration for the island of Oahu and eight stations selected from the University of Hawaii studies. Some of the significant results of these studies are presented. DOE

N79-26515# General Atomic Co., San Diego, Calif.

NUCLEAR CLOSED-CYCLE GAS TURBINE (GT-HTGR): A UTILITY POWER PLANT FOR THE YEAR 2000

Colin F. McDonald Nov. 1978 14 p refs Presented at 17th AIAA Aerospace Sci. Meeting, New Orleans, La., 15 Jan. 1979 (Contract EY-76-C-03-0167)

(GA-A-15184; Conf-790102-4) Avail: NTIS
HC A02/MF A01

The combining of a modern power conversion system such as the closed-cycle gas turbine (CCGT) with an advanced high-temperature gas-cooled reactor (HTGR) results in a power plant well suited to projected utility needs in the late 1990's and early decades of the 21st century. Design aspects of the GT-HTGR plant in its present conceptual design stage are discussed. The established technology bases for the GT-HTGR power plant are outlined, and emphasis is placed on the design and development of the helium turbomachine. The benefits of the nuclear gas turbine power plant are presented, and it is concluded that the worldwide efforts to bring it into use should increase. DOE

N79-26517# Acurex Corp., Mountain View, Calif.
DESIGN OF A 150 kW_e DISTRIBUTED COLLECTOR SOLAR THERMAL POWER STATION

Gary J. Neuner 1978 23 p refs Presented at Symp. on Solar-Thermal Power Sta., Cologne, 12 Apr. 1978 (AED-Conf-78-212-013; Conf-780425-9) Avail: NTIS
HC A02/MF A01

A large-scale solar energy system for generating 150 kW_e of electricity is described. The solar system is to be built near Coolidge, Arizona. Using a distributed collector field of Acurex concentrating solar collectors, electricity will be used to pump irrigation water. Concentrators are oriented north-south to collect the most energy in the summer months when irrigation demand is highest. Exxon Caloria HT-43 heat-transfer oil is circulated through the collector field and heated to 590 K, then either transferred into a thermal storage tank or pumped directly to an organic Rankine-cycle turbine. Thermal storage consists of a tank, filled with Caloria HT-43 and rocks. Power generation is provided by Sundstrand organic Rankine-cycle power conversion system. Hot oil from the collector field is used to boil toluene, which in turn passes through a turbine to generate electricity. The power distribution system includes a 12.5 kV 3-phase distribution feeder to the well pumps. DOE

N79-26518# Brookhaven National Lab., Upton, N. Y.
HYDROGEN STORAGE DEVICES FOR AUTOMOBILES

G. Strickland 1978 10 p refs
(Contract EY-76-C-02-0016)
(BNL-25263) Avail: NTIS HC A02/MF A01

Three hydrogen storage devices are discussed. The first two, a cryogenic container (Dewar) of liquid hydrogen (LH₂) and a pressure vessel filled with metal hydride (reservoir), were successfully demonstrated in working vehicles; whereas the third is a low-pressure container of glass microballoons containing highly pressurized hydrogen and is still in the conceptual stage. Each of these devices supplies hydrogen to an internal-combustion engine modified for hydrogen service. DOE

N79-26519# Argonne National Lab., Ill.
EVALUATION OF AVAILABLE MHD SEED-REGENERATION PROCESSES ON THE BASIS OF ENERGY CONSIDERATIONS

A. C. Sheth and T. R. Johnson Sep. 1978 43 p refs
(Contract W-31-109-eng-38)
(ANL/MHD-78-4) Avail: NTIS HC A03/MF A01

Of the several processes described in the literature that are capable of separating sulfur from alkali-metal sulfates, seven processes were selected as candidates for regenerating seed material for reuse in open-cycle MHD. After a brief assessment of each process, two were selected for a detailed analysis. The processes were compared on the bases of energy requirements and the amount of research work needed to develop a seed-regeneration process for MHD systems. The energy requirements given should be considered as rough values, because factors such as heat losses and component efficiency were not included in the analysis. On the basis of energy consumption, the PERC process has a slight advantage over the Tampella process; on the basis of the present state of development of various components, the Tampella process has a clear advantage. Accordingly, it was recommended that development programs be carried out for both the PERC and Tampella processes. DOE

N79-26522# Arizona State Univ., Tempe. Dept. of Botany and Microbiology.

WORKSHOP ON ECOLOGICAL IMPACTS OF SOLAR ENERGY CONVERSION

Duncan T. Patten 1978 26 p Workshop held at Tempe, Ariz., 11-12 May 1978
(Contract EG-77-S-02-4339)
(COO-4339-4) Avail: NTIS HC A03/MF A01

The first phase of the workshop was an attempt to prioritize the impact parameters and establish some form of research program to evaluate these impacts. The second phase was to establish priority research and program needs for monitoring the impacts of the planned Solar Thermal Power System to be constructed near Barstow, California. This monitoring and research program is to be designed to be applicable to other proposed solar powered systems and should include impacts of all phases of construction, operation, and maintenance. DOE

N79-26524# California Univ., Livermore. Lawrence Livermore Lab.

ELECTRIC POWER FROM LASER FUSION: THE HY LIFE CONCEPT

M. Monsler, J. Bink, J. Hovingh, W. Meier, P. Walker, and J. Maniscalco (Exxon Research and Engineering Co., Linden, N. J.) Jun. 1978 20 p refs Presented at 13th Intersoc. Energy Conversion Engr. Conf., San Diego, Calif., 20 Aug. 1978 Revised

(Contract W-7405-eng-48)
(UCRL-81259-Rev-1; Conf-780801-40) Avail: NTIS
HC A02/MF A01

A high yield lithium injection fusion energy chamber is described which can conceptually be operated with pulsed yields of several thousand megajoules a few times a second, using less than one percent of the gross thermal power to circulate the lithium. Because a one meter thick blanket of lithium protects the structure, no first wall replacement is envisioned for the life of the power plant. The induced radioactivity is reduced by an order of magnitude over solid blanket concepts. The design calls for the use of common ferritic steels and a power density approaching that of a LWR, promising shortened development times over other fusion concepts and reactor vessel costs comparable to a LMFB. DOE

N79-26625# Lincoln Lab., Mass. Inst. of Tech., Lexington.
COMBINED PHOTOVOLTAIC AND THERMAL HYBRID COLLECTOR SYSTEMS

E. C. Kern, Jr. and M. C. Rissell 1978 6 p refs Presented at IEEE Photovoltaic Specialists Conf., Washington, D. C., 5 Jun. 1978

(Contract EG-77-S-02-4577)
(COO-4577-3; Conf-780619-24) Avail: NTIS
HC A02/MF A01

Solar energy collectors that produce both electric and thermal energy were investigated as an attractive alternative to individual thermal and photovoltaic collectors for certain applications and climates. Economic results from a system analysis indicate that hybrid collector systems are attractive in small buildings that have substantial heating loads. Passively cooled photovoltaic panels are best suited for structures located in regions where year-round air conditioning and small, low-grade, thermal energy demands predominate. DOE

N79-26527# Oak Ridge National Lab., Tenn.
USE OF WASTE HEAT FROM NUCLEAR POWER PLANTS

M. Olszewski 1978 19 p refs Presented at Environ. Control Symp., Wash., D. C., 28 Nov. 1978
(Contract W-7405-eng-26)
(CONF-7811109-4) Avail: NTIS HC A02/MF A01

Utilization of power plant reject heat was studied. A brief description of the historical development of the program is given and results of recent studies are outlined to indicate the scope of present efforts. A description of a project assessing uses for reject heat from the Vermont Yankee Nuclear Station is also given. DOE

N79-26528# Sandia Labs., Albuquerque, N. Mex.
PROCEEDINGS OF THE WORKSHOP ON MECHANICAL STORAGE OF WIND ENERGY

Jan. 1979 150 p ref Workshop held at Albuquerque, N. Mex., 14 Dec. 1978

(Contract EY-76-C-04-0789)

(SAND-79-0001) Avail: NTIS HC A07/MF A01

Information is summarized on (1) flywheel interface and storage technology for photovoltaic applications; (2) a simulation model for wind energy systems; (3) planned FY 79 SERI tasks in storage and wind; (4) energy storage technology development to support the DOE wind energy program; (5) wind energy conversion system storage needs; (6) energy conversion and storage; and (7) SLA systems analysis results. DOE

N79-26529# Argonne National Lab., Ill.
HYCSOS CHEMICAL HEAT PUMP AND ENERGY CONVERSION SYSTEM Status Report

D. M. Gruen, M. Mendelsohn, I. Sheft, and G. Lamich 1978 12 p refs Presented at Hydride Contractors' Review Meeting, Wash., D. C., 28-29 Nov. 1978

(Contract W-31-109-eng-38)

(CONF-781142-7) Avail: NTIS HC A02/MF A01

An efficient and cost competitive chemical heat pump and energy conversion system driven by solar, other low grade heat sources or by fossil fuels (gas or oil) is discussed. The HYCSOS concept involves the use of two different metal hydrides with different free energies of formation enabling hydrogen to flow from one to another of the hydrides under the influence of appropriate thermal gradients. In the chemical heat pump mode, hydrogen flows between two pairs of four vessels which take the place of the generator/condenser and evaporator/absorber elements of conventional absorption refrigerators. The functions of generator/absorber and condenser/evaporator are interchanges at the end of each two minute cycle. The chemical heat pump materials are based on the AB5 alloys which combine a remarkable ability to absorb hydrogen rapidly and reversibly at moderate pressures near ambient temperatures with a large hydrogen storage capacity. DOE

N79-26530# Sandia Labs., Albuquerque, N. Mex.
SYSTEM STUDY ON THE FEASIBILITY OF A COAL-FIRED TOTAL-ENERGY PLANT (WITH SOLAR OPTIONS) FOR SANDIA LABORATORIES

S. Thunborg, Jr. and James A. Leonard Dec. 1978 26 p

(Contract EY-76-C-04-0789)

(SAND-78-0979) Avail: NTIS HC A03/MF A01

A preliminary assessment is presented of the technical and economic feasibility of a coal-fired total-energy onsite plant that could furnish much of the thermal electrical power requirements of the Department of Energy's facilities in Albuquerque, NM. A conceptual design and analysis of a solar-energy system that could be colocated with the coal-fired plant as a solar-total-energy system experiment is included. In general, the analysis indicates that a coal-fired total energy system is economically feasible. Further, the solar supplement to the coal-fired system can be an effective utilization of solar energy. However, the cost of the energy from the solar supplement will be from \$7 MBTU to \$13 MBTU depending on the solar supplement system used. DOE

N79-26531# Electricite de France, Chatou. Div. Technique des Energies Nouvelles.

GEOHERMAL HEATING WITH HEAT PUMPS [LE CHAUFFAGE GEOTHERMIQUE AVEC POMPE A CHALEUR]

1978 16 p In FRENCH Original contains color illustrations Avail: NTIS HC A02/MF A01

The application of geothermal energy conversion to heating is described. One class of heat pumps was analyzed. Their coupling with a geothermal source allows for satisfactory heating. Performances are given. Particular attention is paid to optimal utilization given the external temperature. Author (ESA)

N79-26532# Electricite de France, Paris. Div. Conversion Electrochimique.

THE USE OF FUEL CELL ION EXCHANGE MEMBRANES IN ELECTROLYTIC CELLS [LES MEMBRANES ECHANGEUSES D'IONS DES PILES A COMBUSTIBLES]

Alain Damien and Jean-Claude Sohm (Ecole Natl. Super. d'Electrochim. et d'Electromet.) Jun. 1977 24 p refs In FRENCH

(P/539/77/23) Avail: NTIS HC A02/MF A01

Ion exchange membranes, previously used in fuel cells, were studied in order to examine their application to water electrolysis. State-of-the-art is reviewed from the bibliography, comparing this process with a classic one. Results show that only the cationic membranes are adequate for electrolytic cell use, being sufficiently resistant to heat and oxidation.

Author (ESA)

N79-26534# Electricite de France, Chatou.
ANALYSIS OF HELIO-THERMOELECTRICAL ENERGY CONVERSION EFFICIENCY [ANALYSE ENERGETIQUE DE LA CONVERSION HELIOTHERMO-ELECTRIQUE]

T. S. Tran Feb. 1977 136 p refs In FRENCH

(Rept-77/HP-40-241) Avail: NTIS HC A07/MF A01

The whole process of indirect conversion of solar energy to electricity is surveyed. A model of sun radiation is discussed considering sun trajectory, local time, and atmospheric as well as meteorological conditions. Optical concentration systems such as linear and punctual concentration, parabolic mirrors, sun-tracking, mirror supports and protections, automation of heliostat fields, etc., are described. Photothermic energy conversion systems are analyzed discussing the dimensioning of radiation boilers, heat-transporting fluids, and losses in solar boilers. Finally, the thermodynamic conversion end is discussed taking into consideration thermodynamic cycle alternatives, specific conversion problems, and fundamental options available. Practical examples referring to the THEM I project in France are presented.

Author (ESA)

N79-26535# Electricite de France, Chatou. Div. Etudes Generales et Methodes.

ELEMENTS FOR TECHNOLOGICAL AND ECONOMIC MODELING OF TOWER-TYPE SOLAR POWER PLANTS [ELEMENTS DE MODELISATION TECHNO-ECONOMIQUE D'UNE CENTRALE ELECTROSOLAIRE A TOUR]

G. Manteau Jan. 1977 110 p refs In FRENCH

(P/51/76/17) Avail: NTIS HC A06/MF A01

Fixed parameters relative to the investment cost of a solar powered turbogenerator are studied. A numerical analysis is done for a type THEM 1 solar power station; the effects of certain investment cost parameters on feasibility are studied for this case. Suggestions for improvement on the design and for alternative applications of the model are offered. An optimal size for solar facilities to obtain an optimal output value vis a vis costs and foreseen demand is also discussed. Author (ESA)

N79-26536# Electricite de France, Chatou. Service Machines et Automatismes de Production.

COST/BENEFIT ANALYSIS OF A SOLAR POWER PLANT SUPPLEMENTED BY DIESEL GENERATION IN COMPARISON WITH A SOLELY DIESEL SYSTEM - OPTIMIZING FOR SIZE AND INITIAL INVESTMENT IN AN ISOLATED AREA [POSSIBILITE DE PLACEMENT ET DEMENSIONNEMENT OPTIMAL D'UNE CENTRALE ELECTROSOLAIRE A TOUR ASSOCIEE A UN DIESEL DANS UN CENTRE ISOLE]

G. Manteau Apr. 1977 29 p refs In FRENCH

(P/51/77/21) Avail: NTIS HC A03/MF A01

Economic and climatic conditions pertinent to the installation of a solar power plant are studied. The reduction of kWh cost vis a vis wholly diesel electrical energy generation is considered. The tradeoff between installation size and optimal output value is defined and identified for the two systems respectively. The study is hypothetical and is intended only as a guideline for future real market surveys. Author (ESA)

N79-26537# Electricite de France, Chatou. Service Machines et Automatismes de Production.

STUDY OF LOW OUTPUT SOLAR ENERGY POWER PLANTS [RAPPORT DE STAGE: ETUDE DE CENTRALE SOLAIRES DE FAIBLE PUISSANCE]

P. Ribiere and P. Weyland May 1977 138 p refs In FRENCH

(P/51/77/24) Avail: NTIS HC A07/MF A01

Various components used in combination with solar energy to produce a thermodynamic effect in a low output (less than or equal to 1MW) power generating system are studied in order to determine their economic feasibility. Four possible installations are envisaged and evaluated for their cost vis a vis the energy obtained. These are mini solar power plants (2.3 to 50 kw output) with fixed collectors, solar heat sinks with chemical or mechanical energy conversion, solar power plants (200 kw nominal output) with heliostat collectors, and tower-type solar power plants (for a nominal output of 1 MW). Related technologies such as bio-conversion, chemical reactors, and electrical energy storage are discussed and related to the size of the solar power plant chosen.

Author (ESA)

N79-26538# Kentucky Univ., Lexington. Inst. of Mining and Minerals Research.

A KENTUCKY ENERGY RESOURCE UTILIZATION PROGRAM Semiannual Report, 1 Jan. - 30 Jun. 1978

Dec. 1978 77 p refs

(PB-292949/5; IMMR43-PR7-78)

Avail: NTIS

HC A05/MF A01 CSCL 081

The extension and expansion of the program undertaken by the Institute for Mining and Minerals Research (IMMR) during the 1972-1974 biennium, and further expanded during the 1974-1976 biennium is described. The IMMR is the prime contractor for research and development to the Kentucky Department of Energy. The program is organized into three major functional categories, each with an operating division: materials, process development, and resources, recovery and reclamation. A summary of activities for each division for the reporting period is included.

GRA

N79-26539# Seton, Johnson and Odell, Inc., Portland, Ore. **ENVIRONMENTAL MANAGEMENT AND ENERGY FACILITY SITING IN THE COASTAL ZONE Final Report**

25 Aug. 1978 161 p refs Prepared in cooperation with Cogan and Associates, Portland, Ore.

(Contract EPA-68-01-3955)

(PB-292947/9) Avail: NTIS HC A08/MF A01 CSCL 10A

The issue of integrating air and water quality planning, coastal zone management, and energy facility siting activities in coastal areas of California, Oregon, and Washington was studied. The study considered exploration, extraction, refining, storage, transfer, and shipment of oil and gas; thermal power plants; and construction and fabrication yards for oil drilling equipment to be used on the outer continental shelf. After identifying problems in the regulatory process, recommendations were developed to deal with these problems and included suggestions to consolidate the state and federal environmental review procedures, reduce duplication in permit applications, and clarify interagency relationships.

GRA

N79-26541# Indian Inst. of Science, Bangalore. Dept. of Aeronautical Engineering.

A LOW-COST WATER PUMPING WINDMILL USING A SAIL TYPE SAVONIUS ROTOR

S. P. Govinda Raju and M. Narasimha Jul. 1979 110 p Sponsored in part by Agency for International Development, Washington, D. C.

(PB-294413/0; Rept-79/FM/2)

Avail: NTIS

HC A06/MF A01 CSCL 10B

A water pumping windmill which can be built largely using materials and skills available in rural areas was designed and fabricated. The windmill uses a Savonius rotor and incorporates a novel sail type construction. The pump is of positive displacement type using the casing of a pneumatic tire for the pumping chamber. Two prototypes were constructed and these indicated a reasonable performance and reliability.

GRA

N79-26542# Appropriate Technology Group, Oskaloosa, Kans. **WIND DRIVEN WATER PUMPS. ECONOMICS, TECHNOLOGY, CURRENT ACTIVITIES**

Steve Blake Dec. 1978 29 p refs Prepared for Intern. Bank for Reconstruct. and Develop.

(PB-292816/6) Copyright. Avail: NTIS HC A03/MF A01 CSCL 10A

The economics and the characteristics typical of the aermotor windmill and the indigenous windmill were discussed. An emphasis was placed upon the importance of supplying this technical information to the developing countries of the world.

GRA

N79-26546# Argonne National Lab., Ill.

CONTROL OF SULFUR DIOXIDE AND PARTICULATE EMISSION IN MHD POWER SYSTEMS USING HIGH SULFUR COAL

K. E. Tempelmeyer, P. Blackburn, A. Sistino, J. Hopfenfeld, and W. Spurgeon (Gilbert Associates) 28 Nov. 1978 22 p refs Presented at Environ. Control Symp., Washington, D. C., 28-30 Nov. 1978

(Contract W-31-109-eng-38)

(CONF-781109-18) Avail: NTIS HC A02/MF A01

The only air pollutant emission standards existing today are for SO₂, NO/sub x/ and particulate matter. There is a high probability that MHD systems will be able to achieve not only the present-day emission limits for the substances but will also be able to comply with anticipated future emission levels of SO/sub x/ and NO/sub x/. The built in processes for the control of SO/sub x/ and NO/sub x/ are described briefly. Particulate emissions in an MHD system will be small submicron particulate flyash particles coated with potassium sulfate, as well as potassium sulfate particles. Electrostatic precipitators and conventional baghouses may provide the means for collection of solid particulates. There is no reason to believe that the control of toxic carcinogenic and heavy metal emissions for MHD systems will represent a problem, either in effectiveness, cost, or convenience which is unique to MHD system.

DOE

N79-26558# Environmental Protection Agency, Washington, D.C. Office of Research and Development.

RESEARCH SUMMARY--OIL SPILLS

Mark Schaefer Feb. 1979 19 p

(PB-293597/1; EPA-600/8-79-007)

Avail: NTIS

HC A02/MF A01 CSCL 13B

Research in the oil spills area is discussed. Current and emerging spill control technologies, the ecological effects of petroleum, and the approach to transferring information about the research program to the appropriate users are included.

GRA

N79-26562# California Univ., Berkeley. Div. of Entomology and Parasitology.

AN EVALUATION OF THE EFFECTS OF GEOTHERMAL ENERGY DEVELOPMENT ON AQUATIC BIOTA IN THE GEYSERS AREA OF CALIFORNIA

Vincent H. Resh, Thomas S. Flynn, Gary A. Lamberti, and Eric McElravy Feb. 1979 63 p refs Sponsored by Interior Dept. (PB-293031/1; W79-04962; OWRT-A-063-CAL(1)) Avail: NTIS HC A04/MF A01 CSCL 13B

Analysis of the response of benthic populations and communities to past and ongoing geothermal energy development and operational practices was undertaken by means of an extensive six site sampling program on Big Sulfur Creek and a concentrated colonization study above, in, and below a heavily impacted tributary (Little Geysers Creek). Differences in species diversity were noted among the six Big Sulfur Creek sites that were selected relative to the presence or absence of natural fumaroles or hot springs and the absence or stage of geothermal energy development. Distribution and colonization patterns of a population of caddisfly, *Gumaga nigricula*, and especially its dominance in high silt areas, suggest that both siltation and fumarole activity may select for certain populations.

GRA

N79-26567# Environmental Protection Agency, Ann Arbor, Mich. Standards Development and Support Branch.

EXHAUST EMISSIONS AND FUEL CONSUMPTION OF A HEAVY-DUTY GASOLINE POWERED VEHICLE OVER VARIOUS DRIVING CYCLES: 361 CUBIC INCH 1966 FORD F-600

Richard Nash Aug. 1978 24 p
(PB-293529/4; HDV-78-08) Avail: NTIS HC A02/MF A01 CSCL 21D

Tests were run on a chassis dynamometer over various cycles. The test sequence was designed to investigate in detail the effect of various driving cycles upon vehicle emissions and fuel consumption. For this reason, road load drag force was not varied. For each driving cycle three tests were run with the vehicle in a fully warmed-up condition. The final phase was a sequence of four tests to investigate cold and warm start effects. GRA

N79-26575# Aerospace Corp., Los Angeles, Calif. Environment and Energy Conservation Div.

DISPOSAL OF BY-PRODUCTS FROM NONREGENERABLE FLUE GAS DESULFURIZATION SYSTEMS Final Report, Dec. 1972 - Mar. 1978

J. Rossoff, R. C. Rossi, R. B. Fling, W. M. Graven, and P. P. Leo Feb. 1979 183 p refs
(Contract EPA-68-02-1010)

(PB-293163/2; EPA-600/7-79-046) Avail: NTIS HC A09/MF A01 CSCL 13B

Untreated and treated wastes from 10 different scrubbers at eastern and western plants using lime, limestone, and double-alkali processes were characterized. Concentrations of salts and trace elements in the wastes were discussed and related to the potential for water pollution. Disposal by ponding, landfilling of chemically fixed wastes, ponding with underdrainage, and conversion to gypsum was assessed. Disposal cost estimates for a 1000 MW eastern plant are 0.55, 0.90, and 1.20 mills/kWh for ponding on indigenous clay, ponding with liner added, and chemical treatment/ landfill, respectively. GRA

N79-26638# Ente Nazionale per l'Energia Elettrica, Milan (Italy). **A MICROMETEOROLOGICAL NETWORK FOR STUDY OF TRANSPORT AND DIFFUSION OF POLLUTANTS IN TWO APENNINE VALLEYS (UNA RETE MICROMETEOROLOGICA PER LO STUDIO DEL TRASPORTO E DELLA DIFFUSIONE DI INQUINANTI IN DUE VALLATE AP-PENNINICHE)**

Marcello Pagliari In Schweiz. Meteorol. Zentralanstalt Proc. of the 15th Intern. Meeting on Alpine Meteorol., Vol. 1 1978 p 60-63 In ITALIAN; ENGLISH summary

Avail: NTIS HC A15/MF A01

Geothermal steam always comes together with gases, such as radon and H₂S, different in composition and quantity from well to well. In the Lardarello basin, the most ancient and developed Italian geothermal area, a meteorological network is now set up, in order to study diffusion and transport of incondensable gases. This network and correlations between different meteorological parameters and different sites are listed. Author

N79-26759# National Oceanic and Atmospheric Administration, Miami, Fla. Atlantic Oceanographic and Meteorological Labs. **DATA FROM THE ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORIES OTEC PLANT SITE STUDY IN THE GULF OF MEXICO, JULY 1977**

Gregg S. Thomas, S. Michael Minton, and Robert L. Molinari Jan. 1979 137 p refs
(PB-293733/2; NOAA-TM-ERL-AOML-34; NOAA-79030710) Avail: NTIS HC A07/MF A01 CSCL 08J

Physical oceanographic data collected in July 1977 at a proposed Ocean Thermal Energy Conversion (OTEC) site in the Gulf of Mexico are presented. Data reduction techniques for all phases of the cruise are also given. All data collected aboard the NOAA Ship Researcher during July 1977 and some XBT

data collected in October and November by the Researcher and Virginia Key are included. Both plots and listings are given for all CSTD, XBT, and Current Meter Profiles. In general, description of the data processing techniques for all data sets is given. GRA

N79-26952# Department of Energy, Washington, D. C. **DEPARTMENT OF ENERGY POLICY FOR FUSION ENERGY**

J. M. Deutch Sep. 1978 29 p
(DOE/ER-0018) Avail: NTIS HC A03/MF A01

The magnetic and inertial fusion research program objectives are described. The various phases of the program are outlined.

Author (DOE)

N79-26953# Argonne National Lab., Ill. **FUSION POWER PROGRAM Quarterly Progress Report, Apr. - Jun. 1978**

C. C. Baker, J. B. Darby, Jr., and S. D. Harkness 1978 108 p refs

(Contract W-31-109-eng-38)
(ANL/FPP-78-2) Avail: NTIS HC A06/MF A01

Abstracts and/or results are presented for investigations in the following research and development areas: reactor materials; energy storage and transfer; tritium containment, recovery and control; advanced reactor design; system studies; neutronics; atomic data; reactor safety; superconducting magnet coils; and other work related to fusion power. Fifty-seven documents by project personnel are also listed. DOE

N79-26979*# Varian Associates, Lexington, Mass. Vacuum Div.

SLICING OF SILICON INTO SHEET MATERIAL: SILICON SHEET GROWTH DEVELOPMENT FOR THE LARGE AREA SILICON SHEET TASK OF THE LOW COST SILICON SOLAR ARRAY PROJECT Quarterly Report, 30 Dec. 1978 - 30 Mar. 1979

J. R. Fleming 30 Mar. 1979 24 p Prepared for DOE and JPL

(Contracts NAS7-100; JPL-954374)
(NASA-CR-158732; DOE/JPL-954374-78/1; S-100-Q12; QR-12) Avail: NTIS HC A02/MF A01 CSCL 20B

Testing of low cost low suspension power slurry vehicles is presented. Cutting oils are unlikely to work, but a mineral oil with additives should be workable. Two different abrasives were tested. A cheaper silicon carbide from Norton gave excellent results except for excessive kerf loss; the particles were too big. An abrasive treated for lubricity showed no lubricity improvement in mineral oil vehicle. The bounce fixture was tested for the first time under constant cut rate conditions (rather than constant force). Although the cut was not completed before the blades broke, the blade lifetime of thin (100 micrometer) blades was 120 times the lifetime without the fixture. The large prototype saw completed a successful run, producing 90% cutting yield (849 wafers) at 20 wafers/cm. Although inexperience with large numbers of wafers caused cleaning breakage to reduce this yield to 74%, the yield was high enough that the concept of the large saw is proven workable. M.M.M.

N79-26980*# Materials Research, Inc., Centerville, Utah. **QUANTITATIVE ANALYSIS OF DEFECTS IN SILICON: SILICON SHEET GROWTH DEVELOPMENT FOR THE LARGE AREA SILICON SHEET TASK OF THE LOW-COST SOLAR ARRAY PROJECT Quarterly Progress Report, 1 Jan. - 31 Mar. 1979**

R. Natesh, J. M. Smith, and H. A. Qidwai 31 Mar. 1979 94 p refs Prepared for DOE and JPL

(Contract JPL-954977)
(NASA-CR-158724; DOE/JPL-954977-79/4; MRI-269; QPR-4) Avail: NTIS HC A05/MF A01 CSCL 20B

The various steps involved in the chemical polishing and etching of silicon samples are described. Data on twins, dislocation pits, and grain boundaries from silicon samples are also discussed. Changes made to upgrade the Quantimet 720 image analysis system are reviewed. A.R.H.

N79-26997 Colorado School of Mines, Golden.

ENTHALPY MEASUREMENTS FOR COAL-DERIVED LIQUIDS Ph.D. Thesis

Gholam-Hossein Omid 1978 183 p

Avail: Univ. Microfilms Order No. 7912225

Experimental enthalpy measurements were made on a liquid derived from a Western Kentucky coal by the char-oil-energy-development process, over the range of 100 to 1500 psia and 122 to 705 F, and also on a distillate derived from this liquid over the range of 119 to 756 F and 60 to 500 psia. The following analyses were made to characterize the coal-liquids: coal-liquids characterization (PERC) method, total carbon-hydrogen-nitrogen analysis, total sulfur analysis, refractive index, PONA analysis, heteroatomic content, and aromatic content. Enthalpy correlations already developed were used to predict the enthalpies of the coal-liquid samples. The results compared better with experimental enthalpies at lower temperatures (approximately 300 F) than at higher temperatures (approximately 700 F). A factor was incorporated in one of the correlations to correct the presence of the heteroatomic compounds in the samples. With this modification, the predicted enthalpies were within the experimental accuracy. Dissert. Abstr.

N79-27018# Oak Ridge National Lab., Tenn. Information Div.

INVENTORY OF DATA BASES, GRAPHICS PACKAGES, AND MODELS IN DEPARTMENT OF ENERGY LABORATORIES

C. R. Shriner, ed. and L. J. Peck, ed. Nov. 1978 278 p refs (Contract W-7405-eng-26)

(ORNL-EIS-144) Avail: NTIS HC A13/MF A01

A central inventory of energy-related environmental bibliographic and numeric data bases, graphics packages, integrated hardware/software systems, and models was compiled to facilitate on-line data retrieval on the DOE/RECON system. The data descriptions are organized under major data types and include descriptions of subject content, documentation, and contact persons. Also provided are computer data such as media on which the item is available size of the item computer on which the item executes, minimum hardware configuration necessary to execute the item, software language(s) and/or data base management system utilized, and character set used. Additional data provided to define the model more accurately include a general statement of algorithms, computational methods, and theories used by the model; organizations currently using the model; the general application area of the model; sources of data utilized by the model; model validation methods, sensitivity analysis, and procedures; and general model classification. DOE

N79-27024# Polytechnic Inst. of New York, Brooklyn. Transportation Training and Research Center.

FUTURE DIRECTIONS FOR PUBLIC TRANSPORTATION: A BASIS FOR DECISION Final Report, Sep. 1977 - Dec. 1978

Anthony J. Weiner, Louis J. Pignataro, Arnold J. Bloch, William H. Crowell, William R. McShane, and Romualdus Sviedrys Dec. 1978 87 p refs

(Contract DOT-UT-NY-11-0017)

(PB-292781/2; UMTA-NY-11-0017-79-1) Avail: NTIS HC A05/MF A01 CSCL 13B

A long range planning study that was prepared to assist the Urban Mass Transportation Administration (UMTA) in its planning to meet the mobility needs of the American population in the coming decades is presented. The authors identified a number of important societal forces and considered reasonable scenarios based upon those forces, with particular attention to the implications for the mobility of people in the public sector. Conclusions and recommendations for future UMTA policy decisions as well as a list of references are provided. GRA

N79-27026# Environmental Research Inst. of Michigan, Ann Arbor.

SEMTAP: A NEW TECHNOLOGY TRANSFER NETWORK TO LINK BUSINESS AND INDUSTRY WITH FEDERAL RESEARCH AND DEVELOPMENT Final Report, Oct. 1976 - Nov. 1978

Mar. 1979 50 p refs

(Grant EDA-99-06-09572)

(PB-292882/8; EDA-79-027) Avail: NTIS HC A04/MF A01 CSCL 05A

The technical assistance study under the Southeastern Michigan Technical Assistance Program (SEMTAP) was established consisting of the Environmental Research Institute of Michigan working with ten community colleges in Southeastern Michigan. The system was intended to demonstrate the effectiveness of providing extensive services directly to local organizations on a wide range of domestic problems which can benefit from information developed by federally sponsored research and development. Business expansion and new job opportunities in Michigan were emphasized. GRA

N79-27086*# National Aeronautics and Space Administration. Langley Research Center, Hampton, Va.

TECHNOLOGY REQUIREMENTS AND READINESS FOR VERY LARGE VEHICLES

D. William Conner Jun. 1979 11 p Presented at the AIAA Very Large Vehicle Conf., Arlington, Va., 26-27 Apr. 1979

(NASA-TM-80127) Avail: NTIS HC A02/MF A01 CSCL 02A

Common concerns of very large vehicles in the areas of economics, transportation system interfaces and operational problems were reviewed regarding their influence on vehicle configurations and technology. Fifty-four technology requirements were identified which are judged to be unique, or particularly critical, to very large vehicles. The requirements were about equally divided among the four general areas of aero/hydrodynamics, propulsion and acoustics, structures, and vehicle systems and operations. The state of technology readiness was judged to be poor to fair for slightly more than one half of the requirements. In the classic disciplinary areas, the state of technology readiness appears to be more advanced than for vehicle systems and operations. S.E.S.

N79-27140*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

TURBINE ENGINE ALTITUDE CHAMBER AND FLIGHT TESTING WITH LIQUID HYDROGEN

E. William Conrad 1979 22 p refs Presented at the Intern. DGLR/DFVLR Symp. on Hydrogen in Air Transportation, Stuttgart, 11-14 Sep. 1979

(NASA-TM-79196; E-062) Avail: NTIS HC A02/MF A01 CSCL 21E

Flight engine experiments using liquid hydrogen fuel were reviewed. A few implications of the results to modern turbine engines are presented. A subsequent contract dealing with a positive displacement pump operating on liquid hydrogen is discussed, and some aspects of liquid hydrogen propellant systems, reflected by rocket booster experience are treated. S.E.S.

N79-27141*# National Aeronautics and Space Administration. Lewis Research Center, Cleveland, Ohio.

ENERGY EFFICIENT AIRCRAFT ENGINES

Roger Chamberlin and Brent Miller 1979 21 p refs Presented at Aircraft Systems Meeting, New York, 20-22 Aug. 1979; sponsored by AIAA

(NASA-TM-79204; E-089) Avail: NTIS HC A02/MF A01 CSCL 21E

The three engine programs that constitute the propulsion portion of NASA's Aircraft Energy Efficiency Program are described, their status indicated, and anticipated improvements in SFC discussed. The three engine programs are (1) Engine Component Improvement--directed at current engines, (2) Energy Efficiency Engine directed at new turbofan engines, and (3) Advanced Turboprops--directed at technology for advanced turboprop-powered aircraft with cruise speeds to Mach 0.8. Unique propulsion system interactive ties to the airframe resulting from engine design features to reduce fuel consumption are discussed. Emphasis is placed on the advanced turboprop since it offers the largest potential fuel savings of the three propulsion programs and also has the strongest interactive ties to the airframe. Author

N79-27221# Pennsylvania State Univ., University Park. Dept. of Aerospace Engineering.
NUCLEAR POWERED SATELLITE STUDIES Annual Progress Report, 1 Jul. 1977 - 30 Jun. 1978
 M. H. Kaplan Jun. 1978 83 p refs
 (Contract EY-78-S-02-4045)
 (COO-4045-3) Avail: NTIS HC A05/MF A01

Pertinent aspects, schedule, personnel, technology developments, and plans are discussed. Support in the area of nuclear space power technology is provided. Results were obtained and communicated to the scientific community including the activities over the past year. DOE

N79-27282# Colorado School of Mines, Golden. Dept. of Chemical and Petroleum Refining Engineering.
ENTHALPY MEASUREMENT OF COAL-DERIVED LIQUIDS Quarterly Technical Progress Report, Apr. - Jun. 1978
 A. J. Kidnay and V. F. Yesavage 1 Aug. 1978 18 p
 (Contract EX-76-C-01-2035)
 (FE-2035-12) Avail: NTIS HC A02/MF A01

Experimental measurements were completed on a middle distillate. A total of 52 enthalpy measurements were made covering the ranges 157 to 675 F and 130 to 1000 psia. DOE

N79-27284# Electricite de France, Paris. Div. Conversion Electrochimique.

BIBLIOGRAPHICAL STUDY OF ELECTROCATALYSIS INVOLVING MIXED OXIDE COMPOUNDS IN AN ALKALINE MEDIUM [ETUDE BIBLIOGRAPHIQUE DE L'ELECTROCATALYSE PAR LES OXYDES MIXTES EN MILIEU ALCALIN]
 Jean Marie Gras May 1977 93 p refs In FRENCH
 (P/539/77/20) Avail: NTIS HC A05/MF A01

Oxides already in use as hydrogen and oxygen electrodes are listed as well as other oxide compounds which have been shown experimentally to be of interest as catalysts. Their electrochemical properties are extensively examined in order to determine their potential for reducing anodic and cathodic overvoltage in hydrogen oxygen fuel cells and in electrolytic cells. The preparation of these compounds is also discussed. No catalyst being simultaneously a good conductor, resistant to anodic dissolution, and having good catalytic characteristics was found. However, results show nickel resists anodic corrosion and directs electron flow even though its electrocatalytic activity is rather poor. Author (ESA)

N79-27313# Kewanee Oil Co., Shidler, Okla.
NORTH STANLEY POLYMER DEMONSTRATION PROJECT Final Annual Report
 B. M. DuBois Nov. 1978 92 p
 (Contract ET-76-C-03-1805)
 (BETC/RI-78/19; FAR-3) Avail: NTIS HC A05/MF A01

The efficiency of polymer enhanced water flooding in a sandstone reservoir is examined to determine the economic feasibility of the project. The present production response and the projected trends are reported. DOE

N79-27320 Colorado School of Mines, Golden.
KINETICS OF COAL LIQUEFACTION TO PRE-ASPHALTENES, ASPHALTENES AND OILS Ph.D. Thesis
 Mazen Ahmad Shelabi 1978 168 p
 Avail: Univ. Microfilms Order No. 7912231

The kinetics and mechanism of coal liquefaction was studied in a 300 cc magnedrive autoclave batch reactor. The reactions were conducted with a ratio of coal to solvent (tetralin) of 1:10 and under a hydrogen blanket at a total pressure of 2000 psi. Three temperatures were investigated: 350, 375 and 400 C. Three models involving first order irreversible series/parallel reactions were discriminated for the raw data using a non-linear parameter estimation technique. The model that exhibited the lowest value of the determinant of moment matrix of residuals was considered the best in explaining the mechanism of coal dissolution. Arrhenius activation energies were calculated for each rate constant. The values ranged between 10-50 K cal/g mole. The high activation energies implied that the reactions of coal

hydroliquefaction are kinetically controlled and not controlled by interfacial mass transfer. Dissert. Abstr.

N79-27321*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
COMPATIBILITY OF ELASTOMERS IN ALTERNATE JET FUELS

S. H. Kalfayan, R. F. Fedors, and W. W. Reilly 1 Jun. 1979 70 p refs
 (Contract NAS7-100)
 (NASA-CR-158773; JPL-Pub-79-28) Avail: NTIS HC A04/MF A01 CSCL 21D

The compatibility of elastomeric compositions of known resistance to aircraft fuels was tested for potential use in Jet A type fuels obtainable from alternate sources, such as coal. Since such fuels were not available at the time, synthetic alternate fuels were prepared by adding tetralin to a petroleum based Jet A type fuel to simulate coal derived fuels which are expected to contain higher amounts of aromatic and hydroaromatic hydrocarbons. The elastomeric compounds tested were based on butadiene-acrylonitrile rubber, a castable Thiokol polysulfide rubber, and a castable fluorosilicone rubber. Batches of various cross-link densities of these rubbers were made and their chemical stress relaxation behavior in fuel, air, and nitrogen, their swelling properties, and response to mechanical testing were determined. Author

N79-27322# Committee on Appropriations (U. S. Senate).
ALCOHOL FUELS

Washington GPO 1978 712 p refs Special hearing before the Comm. on Appropriations, 95th Congr., 2d Sess., 1978 (GPO-22-334) Avail: SOD HC

The potential value of alcohols as an additional energy source was presented. Gasohol fuel production, uses, and combustion efficiency were discussed. M.M.M.

N79-27327# Battelle Pacific Northwest Labs., Richland, Wash.
INVESTIGATION OF GASIFICATION OF BIOMASS IN THE PRESENCE OF CATALYSTS

L. K. Mudge, L. J. Sealock, Jr., R. J. Robertus, D. H. Mitchell, E. G. Baker, and P. C. Walkup 1978 34 p refs Presented at 5th Biomass Thermochem. Conversion Coordination Meeting, Richland, Wash., 19-20 Sep. 1978
 (Contract EY-76-C-06-1830)

(CONF-7809125-1) Avail: NTIS HC A03/MF A01

The technical and economic feasibility of catalyzed biomass gasification to produce the specific products methane, hydrogen, carbon monoxide, or synthesis gas for generation of ammonia, methanol, or hydrocarbons are reported. The work in the current reporting period was centered on laboratory studies to determine the relative activity of Na₂CO₃ and trona and 3 1/2 times as much as borax or uncatalyzed wood at both 550 and 650 C. The effect of biomass composition on gas production was determined by gasifying wood, bark, and cellulose. In all cases bark samples produced more gas than their respective woods. The use of combined catalysts to optimize methane production was studied. Initial screening of catalysts was begun. The design, procurement, and installation of the process development unit is described. DOE

N79-27329# Pittsburgh and Midway Coal Mining Co., Shawnee Mission, Kans.

SOLVENT REFINED COAL (SRC) PROCESS: ENVIRONMENTAL PROGRAM. VOLUME 3: PILOT PLANT DEVELOPMENT WORK, PART 5 Interim Report, 1 Jul. 1977 - 30 Jun. 1978

Jan. 1979 56 p refs Prepared by Alsid, Snowden and Associates
 (Contract EX-76-C-01-0496)

(FE-0496-T8; IR-27) Avail: NTIS HC A04/MF A01

Baseline studies of air and water quality were performed before the pilot plant was constructed. Similar studies were made in 1976 during plant operation. These studies indicate that the pilot plant had virtually no measurable impact on air and water quality in the surrounding environment. As a result of the 1976 study, the monitoring frequency was reduced to alternate monthly water and air samples with an annual foliage observation. The

results of the 1976-78 years of monitoring indicate that no substantial change in the environment occurred as a result of the SRC plant. DOE

N79-27330# Brigham Young Univ., Provo, Utah.
MIXING AND KINETIC PROCESSES IN PULVERIZED COAL COMBUSTORS

L. D. Smoot Aug. 1978 31 p refs
 (EPRI Proj. 364-1)

(EPRI-FP-806-SY) Avail: NTIS HC A03/MF A01

An atmospheric coal combustion furnace which feeds up to 57 kg of coal per hour was constructed in sections with one section containing several sampling probes. The probes allow for simultaneous gas-particulate sampling and are positioned in the reactor to sample both radially and axially. The use of gas and particulate tracers in conjunction with the sampling and analysis permits the determination of: (1) the local extent of mixing of primary and secondary gases; (2) the local extent of particle dispersion; (3) the local extent of particle reaction; and (4) the local extent of pollutant formation. Two additional tasks supported the combustion testing, a pulverized coal furnace modeling development and a series of cold-flow jet mixing experiments. Two computer models were identified. Cold-flow tests investigated the mixing characteristics of particle laden, confined jets under conditions that simulate the operations of industrial pulverized coal furnaces and gasifiers but without chemical reaction. The effects of geometry and flow conditions were investigated in 120 cold tests. ERA

N79-27331# Braun (C. F.) and Co., Alhambra, Calif.
COAL GASIFICATION, COMMERCIAL CONCEPTS, GAS COST GUIDELINES, REVISION 1 Final Report

R. Skamser Aug. 1978 40 p refs Revised
 (Contract EX-76-C-01-2240)

(FE-2240-100) Avail: NTIS HC A03/MF A01

The guidelines contain all the information and procedures that are required to calculate, on a consistent basis, the cost of producing high Btu pipeline quality gas from coal. The design basis for coal gasification plants is presented. Coal analyses, environmental requirements, plant size, equipment design guides, and equations for gas costs were included using either utility or private investor financing. The cost of gas was determined primarily by the plant investment which is obtained from estimates of the installed cost of equipment. DOE

N79-27332# Department of Energy, Pittsburgh, Pa. Energy Research Center.

STABILITY OF COAL-OIL MIXTURES

J. M. Ekmann and D. Bienstock 1978 28 p refs Presented at 1st Intern. Symp. Coal Oil Mixture Combustion, St. Petersburg, Fla., 8 May 1978

(CONF-7805152-1) Avail: NTIS HC A03/MF A01

The settling behavior of both stabilized and nonstabilized coal-oil mixtures was investigated. Thirteen stabilizers were tested under standardized conditions. Several were found to be partially effective for the coal-oil combination studied. The majority provided no improvement over the nonstabilized mixture and, in fact, decreased the stability in some cases. A fifty percent mixture was found to be stable in the oil used for the stabilizer tests. The viscosity data are of value in predicting pressure drop in pipeline flow and may be used, in conjunction with the settling curves, to compare simple models of sedimentation, and to identify the mechanisms of settling in coal-oil mixtures. DOE

N79-27333# Hamilton Standard, Windsor Locks, Conn.
METHANE PRODUCTION FROM BEEF CATTLE FEED-LOTS

D. J. Lizdas 1978 22 p refs Presented at 2d Symp. on Fuels from Biomass, Troy, N. Y., 20 Jun. 1978
 (Contracts EY-76-C-02-2952; EG-77-C-01-4015)

(CONF-7806107-2) Avail: NTIS HC A02/MF A01

The residues from beef cattle in feedlots provide an easily collectible source of biomass that can be converted to fuel gas and other useful products. The status of two programs are described and presented. The first program was a pilot scale evaluation to determine the feasibility of producing methane and a cattle refeed product from dirt feedlot residues using anaerobic

fermentation. The second was for design, construction and operation of a full scale anaerobic fermentation facility to identify the technical and economic viability of producing fuel gas and a refeed product from the residues from an environmental beef cattle feedlot. DOE

N79-27336# Department of Energy, Washington, D. C. Office of Regulations and Emergency Planning.

FINDINGS AND VIEWS CONCERNING THE EXEMPTION OF AVIATION GASOLINE FROM THE MANDATORY PETROLEUM ALLOCATION AND PRICE REGULATIONS

Jun. 1978 85 p

(DOE/ERA-0024) Avail: NTIS HC A05/MF A01

An added section to the regulation which requires that any amendment submitted to the Congress for the purpose of exempting a petroleum product or refined product category from regulation be supported with certain findings and views on a variety of matters related to the exemption was presented. Based on an analysis of historic and projected supply, demand, and price trends, the DOE concluded that allocation and price controls are no longer necessary for aviation gasoline and that its exemption in addition to satisfying the other requisite criteria of Section 12 of the EPAA, consistent with the attainment of the objectives specified in Section 4 (b)(1) of the EPAA. DOE

N79-27337# Department of Energy, Washington, D. C. Energy Information Admin.

THE 1980 MOTOR GASOLINE SUPPLY AND DEMAND. ANALYSIS MEMORANDUM AM/ES/79-12

E. Tukenmez, R. Farmer, H. McDaniel, C. Everett, and H. Walton Dec. 1978 44 p

(DOE/EIA-0102/32) Avail: NTIS HC A03/MF A01

For 1980 motor gasoline consumption is projected to range from 7.58 to 7.96 MMB/D depending on the level of economic activity and the extent of improvement in the fuel efficiency of the automobile fleet. Depending on the state of the economy, low levels of conservation indicate a range of 1980 consumption levels which vary from 7.88 to 7.96 MMB/D. With high conservation the levels are from 7.58 to 7.66 MMB/D. With 1980 consumption of motor gasoline at these projected levels, the refining industry will have to take certain actions to increase supplies, particularly to offset the effects of the sharp phasedown of octane-increasing lead additives. The industry will be required to reduce the lead level to about 0.5 grams per gallon by October, putting pressure on downstream refinery units which make high octane clear pool gasoline. The estimated effect of this phasedown is a reduction of possible gasoline output by about 500 thousand barrels per day in 1980. DOE

N79-27338# Toronto Univ. (Ontario). Dept. of Chemical Engineering and Applied Chemistry.

MATERIAL AND ENERGY BALANCES IN THE PRODUCTION OF ETHANOL FROM WOOD

Morris Wayman, J. H. Lora, and E. Gulbinas 1978 19 p refs Presented at Symp. on Chem. for Energy, Winnipeg, Canada, Jun. 1978

(CONF-7806139-1) Avail: NTIS HC A02/MF A01

Experimental production of ethanol from aspen wood gave yields of 70.7% or 83.4% when acid hydrolysis or enzymatic hydrolysis were used after autohydrolysis and extraction of lignin. These were, respectively, 58.4 and 68.9 gallons of 95% ethanol per ton of aspen wood (dry basis). In addition 426 lb of lignin with heat of combustion 11,100 Btu/lb were obtained per ton of wood. Multi-stage hydrolysis was beneficial for both acid and enzymatic hydrolysis, 80% and over 99% of theoretical yields of sugar being obtained by the two processes. Economic estimates show a significant advantage in investment and operating costs for the enzymatic process. The price of 95% ethanol, including a reasonable return on investment by this process is estimated at \$1.34/gallon. DOE

N79-27339# Mathematica, Inc., Princeton, N. J.
COAL LIQUEFACTION: REPORT ON A FOCUS GROUP DISCUSSION

Irving Crespi 10 Nov. 1978 53 p

(Contract EV-78-C-01-6388)

(DOE/TIC-10039) Avail: NTIS HC A04/MF A01

The consensus was that demonstration projects are needed for all coal liquefaction processes and that it is premature to narrow consideration to only one or two. Although the various processes are technically different, the end-use products are said to be essentially interchangeable. The general feeling is that, at this time, little is known about the comparative technical problems, costs, and market potential of SRC-2 as compared with other coal liquefaction processes. Government financing is felt to be essential. It was agreed that the potential market for coal liquefaction products is primarily for use in oil boilers and not in motor fuels. DOE

N79-27341# Versuchsanstalt fuer Geoelektrik und Blitzschutz, Vienna (Austria).

INVESTIGATION OF FLOW PHENOMENA IN PULVERIZED COAL GASIFICATION FOR THE NEW PROCESS Final Report

Richard Jung Bonn Bundesmin. fuer Forsch. u. Technol Dec. 1978 137 p refs In GERMAN; ENGLISH summary Sponsored by Bundesmin. fuer Forsch. u. Technol. (BMFT-FB-T-78-27) Avail: NTIS HC A07/MF A01; Fachinformationszentrum Karlsruhe, West Ger. DM 28.60

The influence of flow conditions on the distribution of pulverized coal in gaseous fluids was studied. Experiments on a model provided the fundamentals for the design and calculation of flow routes in the oxidation and degasification stages as well as a confirmation of the calculation method for cyclone separators known from the literature. The results obtained can be applied to industrial plant design. Author (ESA)

N79-27342# Institute of Gas Technology, Chicago, Ill.

EVALUATION OF THE FLASH DESULFURIZATION PROCESS FOR COAL CLEANING Final Report, Nov. 1975 - Jun. 1977

Donald K. Fleming and Robert D. Smith Jan. 1979 155 p refs

(Contract EPA-68-02-2126)

(PB-292328/2; EPA-600/7-79-016)

Avail: NTIS

HC A08/MF A01 CSCL 21D

Results of a program to develop (on the laboratory, bench, and pilot scale) operating conditions for key steps in the flash process for desulfurizing coal by chemical and thermal treatment are given. Laboratory and bench scale data on high-sulfur eastern U.S. coals prove that the process can reduce sulfur to the point that the resulting solid fossil fuel can be directly consumed in compliance with current regulations for SO_x emissions. Because of operating and technical difficulties pilot scale test data are inconclusive. As conceived, the process incorporated a material that has a greater chemical affinity for the sulfur than the coal has. Use of a sulfur-getter is required to reduce the H₂S concentration in the gas. Data indicate that the concept is sound. GRA

N79-27345# Institut fuer das Bauen mit Kunststoffen e.V., Darmstadt (West Germany).

DESCRIPTION OF THE POSSIBILITIES FOR ENERGY SAVINGS DURING THE DESIGN AND CONSTRUCTION OF APERTURES IN BUILDINGS (CROSS-SECTION REPORT) Final Report

Gerhardt Knappke Bonn Bundesmin. fuer Forsch. u. Technol. Sep. 1978 118 p refs In GERMAN; ENGLISH summary Sponsored by Bundesmin. fuer Forsch. u. Technol. (BMFT-FB-T-78-15) Avail: NTIS HC A06/MF A01; Fachinformationszentrum Karlsruhe, West Ger. DM 24.80

Various sources of energy loss in buildings are discussed to determine the necessary improvements in windows, doors, skylights, etc for new and old buildings. Indications of the way in which the energy consumption in a building is dependant on the apertures to the outside of the building are given. References are made to existing standards, directives, and specifications. For each case, construction recommendations are given. Author (ESA)

N79-27412# Oak Ridge National Lab., Tenn.

ASSESSMENT OF LOAD MANAGEMENT ON THE ELECTRIC POWER SYSTEM

M. A. Kuliasha and David L. Mohre 1978 8 p Presented at the Joint Natl. ORSA/TIMS Meeting, Los Angeles, 13 Nov. 1978

(Contract W-7405-eng-26)

(CONF-781182-3) Avail: NTIS HC A02/MF A01

The load management program of the division of electric energy systems of the Department of Energy to research, develop, and demonstrate cost effective load management systems is described, and work that was completed is discussed. The program is designed to achieve a balance between near- and long-term electric energy system needs and national energy objectives. It includes the application of refined state-of-the-art analytical methods, technical demonstration of emerging technologies, and the development of advanced concepts and technologies for the future. DOE

N79-27494# Von Karman Inst. for Fluid Dynamics, Rhode-Saint-Genese (Belgium).

LASERS: THEIR APPLICATIONS AND OPERATIONAL REQUIREMENTS

I. J. Spalding In its High-Power Gas Lasers, Vol. 2 1974 26 p refs

Avail: NTIS HC A12/MF A01

Present and potential applications of high power gas lasers to such diverse areas as industrial systems (alignment, Raman scattering, Doppler velocimeters, materials processing, etc.), isotope separation, thermonuclear fusion, military applications, etc. are discussed. Different operational characteristics are required for various laser applications, and these are delineated. A brief introduction is given to the general characteristics of gas lasers, and of gas-dynamics, electrical and chemical methods of excitation. Author

N79-27521# Department of Energy, Washington, D. C. Div. of Transportation Energy Conservation.

DIESEL ORGANIC RANKINE CYCLE COMPOUND ENGINE (BOTTOMING CYCLE) PROGRAM PLAN

Nov. 1978 41 p

(Contract EY-76-C-02-2832)

(DOE/CS-0052) Avail: NTIS HC A03/MF A01

A program plan is presented for implementation of a single vehicle test during fiscal year 1979 in which the diesel organic rankine cycle compound engine installed in a long-haul truck will be tested and evaluated as a precursor to future minifleet demonstration, the ultimate aim of which is the improvement of fuel economy in this class of truck. The single vehicle test consists of two major intertwined phases: the first consists of instrumentation and controls checkout followed by chassis dynamometer tests of the systems and road checkout tests. This is then followed by a series of tests during which all pertinent characteristics of the system will be ascertained. DOE

N79-27546# North American Weather Consultants, Goleta, Calif. **A METHOD OF COMPUTING MAXIMUM GROUND-LEVEL CONCENTRATIONS OF SO₂ UNDER PROLONGED STAGNATION CONDITIONS**

Einar L. Hovind, Max W. Edelstein, and Darryl G. Paulson In NATO Comm. on the Challenges of Mod. Soc. Proc. of the Ninth Intern. Tech. Meeting on Air Pollution Modeling and its Appl. 1978 p 27-35 refs

Avail: NTIS HC A99/MF A01

A technique is described for computing the maximum ground level concentration of SO₂ due to emissions from coal-fired power plants under prolonged stagnation conditions. Factors discussed in the method include wind/mixing height values based on studies of prolonged stagnation conditions, variation in the mixing volume with time, and critical values of SO₂ half-life. The worst case episode is computed by combining the maximum 24-hour concentration on the last day of the episode with the background concentration due to emission buildup from the beginning of the stagnation episode. The resultant computations provide values of relative concentration as a function of distance from the source. Author

N79-27590# ETA Engineering, Inc., Westmont, Ill.
AIR MONITORING NETWORK DESIGN FOR POWER PLANT SITING

Roger K. Raufer, Jay E. Norco, Terry D. Worrell, Richard A. Braun, Joseph E. Marks, and Kenneth E. Noll /in NATO Comm. on the Challenges of Mod. Soc. Proc. of the Ninth Intern. Tech. Meeting on Air Pollution Modeling and its Appl. 1978 p 547-556 refs Prepared in cooperation with Commonwealth Edison Co., Chicago and Illinois Inst. of Tech., Chicago

Avail: NTIS HC A99/MF A01

Recent United States legislation concerning Prevention of Significant Deterioration can require ambient monitoring for proposed large point sources, in both pre-construction and post-construction phases. The design of a monitoring network applicable to both phases is described, using two disparate modeling approaches: an objective technique which allows a quantitative evaluation of each proposed monitor, and multiple source dispersion modeling. The application of the methodology to a proposed power plant in Northern Illinois is described.

Author

N79-27597*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PROCEEDINGS OF THE CONFERENCE ON COAL USE FOR CALIFORNIA

15 Aug. 1978 539 p refs Conf. held at Pasadena, Calif., 9-11 May 1978 Sponsored in part by DOE and the California Energy Commission

(Contract NAS7-100)

(NASA-CR-158770: JPL-Pub-78-56)

Avail: NTIS

HC A23/MF A01 CSCL 10B

The papers, statements, and panel session transcriptions that resulted from the conference are presented. The conference brought together approximately 400 specialists, students, interest groups and general public for the examination of technological, institutional, and social issues surrounding coal use for California and the identification of attendant constraints, impediments, advantages, and target opportunities. The expertise of the participants cover a wide range of subject matter that includes systems examination of coal opportunities, energy demand forecasting, environmental aspects of coal use, coal supply and transport, viewpoint of neighboring states, air pollution control, direct firing, coal gasification and liquefaction technologies, economics of coal use, and the regulatory system.

N79-27598*# Southern California Edison Co., Rosemead.
USING COAL INSIDE CALIFORNIA FOR ELECTRIC POWER

Jack B. Moore /in JPL Proc. of Conf. on Coal Use for California 15 Aug. 1978 p 13-19

Avail: NTIS HC A23/MF A01 CSCL 10B

In a detailed analysis performed at Southern California Edison on a wide variety of technologies, the direct combustion of coal and medium BTU gas from coal were ranked just below nuclear power for future nonpetroleum based electric power generation. As a result, engineering studies were performed for demonstration projects for the direct combustion of coal and medium BTU gas from coal. Graphs are presented for power demand, and power cost. Direct coal combustion and coal gasification processes are presented.

G.Y.

N79-27599*# Battelle Columbus Labs., Ohio.
USING COAL INSIDE CALIFORNIA FOR NONELECTRIC APPLICATIONS

Joseph H. Oxley /in JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 20-32

Avail: NTIS HC A23/MF A01 CSCL 10B

A review of present energy consumption patterns in the manufacturing, transportation, and residential sectors is presented. The properties of coal that affect its substitution into these market sectors are discussed. Specific needs and concerns of Californians are delineated. Present nonelectric consumptive uses of coal in

California are outlined. Current world-wide progress concerning increased industrial use of coal is shown. An overview is given of the options to protect the environment from the direct use of coal, especially from the standpoint of sulfur control; and a time frame for commercialization is projected. Possible desired changes in energy use patterns over the next fifty years are proposed.

G.Y.

N79-27600*# Fluor Engineers and Constructors, Inc., Irvine, Calif.

A SYSTEMS EXAMINATION OF THE OPPORTUNITIES OF COAL FOR CALIFORNIA

W. M. Hathaway /in JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 33-36

Avail: NTIS HC A23/MF A01 CSCL 10B

Because of decreasing availability of petroleum fuels and natural gas, it is imperative that alternative means be developed for meeting demands. The options available for importing energy derived from coal are examined. These include: (1) electric power generated from coal; (2) coal gasification near the mine site for conversion to substitute natural gas or liquid products such as methanol or hydrocarbons; and (3) converting the coal directly to liquid hydrocarbons similar to a synthetic crude oil. Comment is made on the long lead times required between conception and completion of facilities of this type. Because of political and economic impediments, excessive delays have resulted in cancellation of projects. The need for statesmen and citizens with vision and courage to act is summarized.

G.Y.

N79-27601*# California Energy Commission, Sacramento.
Electricity Planning Program.

ELECTRIC ENERGY DEMAND AND SUPPLY PROSPECTS FOR CALIFORNIA

H. G. Mike Jones /in JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 49-52 ref

Avail: NTIS HC A23/MF A01 CSCL 10B

A recent history of electricity forecasting in California is given. Dealing with forecasts and regulatory uncertainty is discussed. Graphs are presented for: (1) Los Angeles Department of Water and Power and Pacific Gas and Electric present and projected reserve margins; (2) California electricity peak demand forecast; and (3) California electricity production.

G.Y.

N79-27602*# Pacific Gas and Electric Co., San Francisco, Calif.
COAL'S ROLE IN CALIFORNIA'S ENERGY NEEDS

Nolan H. Daines /in JPL Proc. of the Conf. on Coal Use for California refs

Avail: NTIS HC A23/MF A01 CSCL 10B

California's post-industrial society demands confidence in the energy supply system as an essential ingredient for social harmony and adequate job creating capital investment. Confidence requires policies which balance supply and demand using believable methods with adequate allowance for the unexpected, reliance on diverse sources and locations, respect for our environment, sustain our individual freedoms and provide opportunities for economic mobility. Coal will play only a part, but an important part, in a multifaceted energy policy using numerous energy sources and systems, conservation techniques, and cooperating societal institutions. Today's extensive and challenging research and development provides the foundation for future technologies which will further resolve the environmental effects associated with coal.

Author

N79-27603*# Atlantic Richfield Co., Harvey, Ill.
ENERGY SUPPLY AND DEMAND IN CALIFORNIA

Edward D. Griffith /in JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 56-60

Avail: NTIS HC A23/MF A01 CSCL 10B

The author expresses his views on future energy demand on the west coast of the United States and how that energy demand translates into demand for major fuels. He identifies the major uncertainties in determining what future demands may

be. The major supply options that are available to meet projected demands and the policy implications that flow from these options are discussed. G.Y.

N79-27604*# Sierra Club, Washington, D.C. Southern California Energy Committee Chair.

POSSIBLE ENVIRONMENTAL EFFECTS OF INCREASED COAL USE IN CALIFORNIA

Dwight L. Carey /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 73-75

Avail: NTIS HC A23/MF A01 CSCL 13B

If coal is to be utilized in California it must be made compatible with the state's drive toward restoring environmental quality. The impacts resulting from coal's mining and transportation, or from water consumption, water quality degradation and electric transmission line routing can probably be adequately mitigated through strong and early planning efforts, the use of improved control and process technologies, and sincere utility commitment. The socioeconomic impacts may prove somewhat more difficult to satisfactorily mitigate. Of greatest concern is adequate control of generated air pollutants and disposal of solid and liquid wastes since acceptable technologies or handling techniques have yet to be conclusively demonstrated. Author

N79-27605*# California Space Shuttle Task Force.

AIR QUALITY AS A CONSTRAINT TO THE USE OF COAL IN CALIFORNIA

Thomas C. Austin /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 76-86 refs

Avail: NTIS HC A23/MF A01 CSCL 13B

Low-NOx burners, wet scrubbing systems, baghouses and ammonia injection systems are feasible for use on large combustion sources such as utility boilers. These devices, used in combination with coal handling techniques which minimize fugitive dust and coal transportation related emissions, should enable new power plants and large industrial boilers to burn coal without the adverse air quality impacts for which coal became notorious. G.Y.

N79-27606*# California State Dept. of Water Resources, Sacramento.

WATER AS A CONSTRAINT TO THE USE OF COAL FOR CALIFORNIA

Ronald B. Robie /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 87-89

Avail: NTIS HC A23/MF A01 CSCL 10B

The constraints for using water to cool coal-fired power plants are discussed. G.Y.

N79-27607*# Bituminous Coal Research, Inc., Monroeville, Pa. **COAL SUPPLY FOR CALIFORNIA**

Joseph J. Yancik /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 111-120 refs

Avail: NTIS HC A23/MF A01 CSCL 08G

The potential sources and qualities of coals available for major utility and industrial consumers in California are examined and analyzed with respect to those factors that would affect the reliability of supplies. Other considerations, such as the requirements and assurances needed by the coal producers to enter into long-term contracts and dedicate large reserves of coal to these contracts are also discussed. Present and potential future mining constraints on coal mine operators are identified and analyzed with respect to their effect on availability of supply. Author

N79-27608*# Energy Transportation Systems, Inc., San Francisco, Calif.

PROSPECTS FOR COAL SLURRY PIPELINES IN CALIFORNIA

John F. Lynch /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 123-126

Avail: NTIS HC A23/MF A01 CSCL 13I

The coal slurry pipeline segment of the transport industry is emerging in the United States. If accepted it will play a vital role in meeting America's urgent energy requirements without public subsidy, tax relief, or federal grants. It is proven technology, ideally suited for transport of an abundant energy resource over thousands of miles to energy short industrial centers and at more than competitive costs. Briefly discussed are the following: (1) history of pipelines; (2) California market potential; (3) slurry technology; (4) environmental benefits; (5) market competition; and (6) a proposed pipeline. G.Y.

N79-27609*# Electric Power Research Inst., Palo Alto, Calif. **STATUS OF NO SUB X CONTROL FOR COAL-FIRED POWER PLANTS**

D. P. Teixeira /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 171-180

Avail: NTIS HC A23/MF A01 CSCL 13B

The status of technologies for controlling emissions of oxides of nitrogen (NOx) from coal-fired power plants is reviewed. A discussion of current technology as well as future NOx control approaches is presented. Advanced combustion approaches are included as well as post-combustion alternatives such as catalytic and noncatalytic ammonia-bases systems and wet scrubbing. Special emphasis is given to unresolved development issues as they relate to practical applications on coal-fired power plants. J.M.S.

N79-27610*# Teknekron, Inc., Berkeley, Calif.

ECONOMIC COMPARISON OF FABRIC FILTERS AND ELECTROSTATIC PRECIPITATORS FOR PARTICULATE CONTROL ON COAL-FIRED UTILITY BOILERS

Peter M. Cukor and Richard A. Chapman /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 183-194

Avail: NTIS HC A23/MF A01 CSCL 13B

The uncertainties and associated costs involved in selecting and designing a particulate control device to meet California's air emission regulations are considered. The basic operating principles of electrostatic precipitators and fabric filters are discussed, and design parameters are identified. The size and resulting cost of the control device as a function of design parameters is illustrated by a case study for an 800 MW coal-fired fired utility boiler burning a typical southwestern subbituminous coal. The cost of selecting an undersized particulate control device is compared with the cost of selecting an oversized device. J.M.S.

N79-27611*# Ultrasystems, Inc., Irvine, Calif.

ECONOMIC CONSIDERATIONS IN CONVERTING FROM OIL/GAS FIRING TO COAL

John G. Rau /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 211-216 refs

Avail: NTIS HC A23/MF A01 CSCL 10B

Economic considerations involved in fuel conversion such as from oil and/or gas firing to coal are discussed including investments costs for new facilities and equipment (including air pollution control equipment), operation and maintenance costs, and purchased fuel costs. An analytical approach to assessing the cost effectiveness of fuel conversion in terms of the annual net cost of conversion, the equivalent annual number of barrels of oil saved, and the integral rate of return of the conversion investment is presented. Illustrative numerical examples are presented for typical utility boilers and industrial boiler facilities. A further consideration addressed deals with the impacts of these costs on the overall financial structure of the firm and the ability of the firm to raise the necessary investment capital. J.M.S.

N79-27612*# Southern California Edison Co., Rosemead. **DIRECT FIRING OF COAL FOR POWER PRODUCTION**

L. T. Papay /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 217-224

Avail: NTIS HC A23/MF A01 CSCL 10B

The use of new technology and advanced emission control hardware to reduce emissions from the direct combustion of coal to produce electricity in California is considered. The technical feasibility of a demonstration project on an existing 81-MW boiler is demonstrated. J.M.S.

N79-27613* Pope, Evans, and Robbins, Inc., New York.
FLUIDIZED COMBUSTION OF COAL
 Michael Pope /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 225-227 refs
 Avail: NTIS HC A23/MF A01 CSCL 10A

A combustion technology that permits the burning of low quality coal, and other fuels, while maintaining stack emissions within State and Federal EPA limits is discussed. Low quality fuels can be burned directly in fluidized beds while taking advantage of low furnace temperatures and chemical activity within the bed to limit SO₂ and NO_x emissions. The excellent heat transfer characteristics of the fluidized beds also result in a reduction of total heat transfer surface requirements. Tests on beds operating at pressures of one to ten atmospheres, at temperatures as high as 1600 F, and with gas velocities in the vicinity of four to twelve feet per second, have proven the concept. The progress that has been made in the development of fluidized bed combustion technology and work currently underway are discussed. J.M.S.

N79-27614* Texaco, Inc., Montebello, Calif.
THE TEXACO COAL GASIFICATION PROCESS FOR MANUFACTURE OF MEDIUM BTU GAS
 W. G. Schlinger /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 243-247 refs

Avail: NTIS HC A23/MF A01 CSCL 10A

The development of the Texaco coal gasification process is discussed with particular emphasis on its close relationship to the fully commercialized Texaco synthesis gas generation process for residual oil gasification. The end uses of the product gas are covered, with special attention to electric power generation via combined cycle technology. Control of SO₂, NO_x, and particulate emissions in the power generating mode is also covered. The application of this technology in a proposed Texaco-Southern California Edison demonstration project is mentioned. Investment information released for a 1000-megawatt advanced combined cycle gasification facility, is also reviewed. J.M.S.

N79-27615* Southern California Gas Co., Los Angeles.
SYNTHETIC NATURAL GAS IN CALIFORNIA: WHEN AND WHY
 W. B. Wood /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 249-252

Avail: NTIS HC A23/MF A01 CSCL 21D

A coal gasification plant planned for northwestern New Mexico to produce 250 MMCFD of pipeline quality gas (SNG) using the German Lurgi process is discussed. The SNG will be commingled with natural gas in existing pipelines for delivery to southern California and the Midwest. Cost of the plant is figured at more than \$1.4 billion in January 1978 dollars with a current inflation rate of \$255,000 for each day of delay. Plant start-up is now scheduled for 1984. J.M.S.

N79-27616* Gulf Mineral Resources Co., Denver, Colo.
STATUS REPORT THE SRC-1 AND SRC-2 PROCESSES

George E. Chenoweth /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 258-261 refs

Avail: NTIS HC A23/MF A01 CSCL 21D

Bench-scale and pilot plant development of solvent refined coal (SRC) processes is reviewed. Large SRC demonstration plants are described. Commercialization of the process is envisioned for the 1980's. J.M.S.

N79-27617* Ashland Oil and Refining Co., Ky.
THE H-COAL PROCESSES: A STATUS REPORT
 William C. Voss /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 262-267

Avail: NTIS HC A23/MF A01 CSCL 21D

A catalytic process (H-Coal) involving the direct hydrogenation of coal to produce hydrocarbon liquids is described. Bench-scale and pilot plant development of the H-Coal process is reported. Emphasis is placed on a proposed pilot plant which will be the largest coal liquefaction plant on-line in the U.S., processing up to 600 tpd of coal. Economic considerations are given. J.M.S.

N79-27618* Exxon Research and Engineering Co., Florham Park, N. J.

EXXON DONOR SOLVENT COAL LIQUEFACTION PROCESSES

W. R. Epperly, L. E. Swabb, Jr., and J. W. Tauton /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 268-272

Avail: NTIS HC A23/MF A01 CSCL 21D

A solvent coal liquefaction process to produce low-sulfur liquid products from a wide range of coals is described. An integrated program of laboratory and engineering research and development in conjunction with operation of a 250 T/D pilot plant is discussed. J.M.S.

N79-27619* Vulcan-Cincinnati, Inc., Ohio.

METHANOL FROM COAL

Donald R. Miller /In JPL Proc. of the Conf. on Coal Use for California 15 Aug. 1978 p 273-277 refs

Avail: NTIS HC A23/MF A01 CSCL 21D

Economic feasibility of methanol or methyl fuel produced from coal using existing technology is discussed. Other factors considered include environmental, safety, toxicity, transportation, so storage, ease of burning, and retrofitting of present boilers. Demonstrations of its uses as a boiler fuel and as a turbine fuel are cited. J.M.S.

N79-27628 International Institute for Applied Systems Analysis, Laxenburg (Austria).

ON FOSSIL FUEL RESERVES AND RESOURCES

Michel Grenon Jun. 1978 46 p refs

(IIASA-RM-78-35) Copyright. Avail: Issuing Activity

Three independent studies assessing fossil fuel resources and reserves of coal, oil, and gas with their possible maximum production until 2020 are presented. Estimates and predictions are based on technical and economic considerations, but exclude political ones. These aspects are put into perspective with the current thinking of the majority of experts in this field and used to estimate some possible future production in relation to demand scenario for the world in the year 2030. Results and conclusions drawn are considered to be conservative.

Author (ESA)

N79-27643* Department of Energy, Washington, D. C. Energy Information Administration.

RE-EXAMINATION OF UNDISCOVERED OIL RESOURCES IN THE UNITED STATES

Dec. 1978 24 p refs

(DOE/EIA-0103/9) Avail: NTIS HC A02/MF A01

An estimate of total producible oil in the United States was determined. Approximately 198 billion barrels are ultimately recoverable and producible of which 113.8 billion barrels were produced through the end of 1977. M.M.M.

N79-27644* Market Facts, Inc., Washington, D. C.
SHAILE OIL: FOCUS GROUP RESULTS

Aug. 1978 74 p

(Contract EV-78-C-01-6458)

(DOE/TIC-10019) Avail: NTIS HC A04/MF A01

The focus group research on oil shale development prepared for the Department of Energy as part of the commercialization program is reported. The research is devoted to evaluation

of the potential for commercialization of oil shale, determination of the barriers to development of this resource, and evaluation of actions required by the federal government to promote commercialization. DOE

N79-27648 California Univ., Los Angeles.
A LARGE SCALE WIND ENERGY PROGRAM FOR THE STATE OF CALIFORNIA Ph.D. Thesis
Matania Ginosar 1978 164 p
Avail: Univ. Microfilms Order No. 7915662

The rationale for a large-scale wind-electric energy program for California is proposed and provided. It is written for decision makers; therefore, simplified calculations and explanations are used throughout. The plan is based on the idea that time is one of the most critical elements in developing renewable energy supplies. The plan concentrates on three areas: (1) wind resource exploration and development; (2) operation testing of existing and new designs; and (3) development of six large-scale wind turbine prototypes suited for California. Dissert. Abstr.

N79-27650 California Univ., Berkeley.
ALGAL GROWTH KINETICS IN BIOCONVERSION OF SOLAR ENERGY Ph.D. Thesis
Joseph Charles Weissman 1978 329 p
Avail: Univ. Microfilms Order No. 7914808

A theoretical and experimental study of algal growth kinetics was undertaken to evaluate potential applications of algal culture in the conversion of solar energy. Models of photosynthesis and nutrient utilization were reviewed and then selectively used to guide studies of hydrogen production and nitrogen fixation by a cyanobacterium, studies of cell feedback and species competition in continuous culture, and experimental outdoor cultivation of algae on wastewater. Nitrogen-limited cultures of the alga *Anabaena cylindrica* were used to produce hydrogen and oxygen continuously for seven to nineteen days. A detailed theoretical and laboratory study was carried out to evaluate various ways of operating continuous hydraulic systems in terms of productivity, stability and species control. Dissert. Abstr.

N79-27652 International Institute for Applied Systems Analysis, Laxenburg (Austria).

A REVIEW OF ENERGY MODELS. PART 4: JULY 1978
J.-M. Beaujean, ed. and J.-P. Charpentier, ed. Jul. 1978 57 p ref

(IASA-RR-78-11-Pt-4) Copyright. Avail: Issuing Activity
Fourteen energy models are classified and briefly reviewed. Previous reviews have shown that energy models linking energy systems to the overall economy are seldom presented. Three models of this type are described. They are the Swedish model, Coal I, and the model of the refining industry in Belgium. Author (ESA)

N79-27653 Commission of the European Communities, Brussels (Belgium).

THE COMPARISON AND COORDINATION OF NATIONAL POLICIES AND PROGRAMS IN THE ENERGY RESEARCH AND DEVELOPMENT SECTOR [LA COMPARAISON ET LA COORDINATION DES POLITIQUES ET PROGRAMMES NATIONAUX DE RECHERCHE ET DEVELOPPEMENT DANS LE SECTEUR DE L'ENERGIE]
1978 184 p In FRENCH

(EUR-5911; ISBN-92-825-0179-5) Copyright. Avail: Issuing Activity

The energy research and development program of the member states of the EEC are compared. The scope of future coordination of policies was investigated under the auspices of CREST. From an inventory of the public sector expenditure of each member state and an identification of priorities, a common program covering energy conservation, geothermal energy, solar energy, hydrogen production, and systems modelling was drawn up. Member states submitted brief outlines of their short and medium term targets and priorities for national energy policies, with broader descriptions of the human and financial resources allocated to programs and projects under way in the public and private sectors. These are given in the appendices. Author (ESA)

N79-27654 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
PERFORMANCE PREDICTION EVALUATION OF CERAMIC MATERIALS IN POINT-FOCUSING SOLAR RECEIVERS
J. Ewing and J. Zwissler 1 Jun. 1979 55 p refs Sponsored in part by DOE
(Contract NAS7-100)

(NASA-CR-158774; JPL-Pub-79-58; DOE/JPL-1060-23) Avail: NTIS HC A04/MF A01 CSCL 10A

A performance prediction was adapted to evaluate the use of ceramic materials in solar receivers for point focusing distributed applications. System requirements were determined including the receiver operating environment and system operating parameters for various engine types. Preliminary receiver designs were evolved from these system requirements. Specific receiver designs were then evaluated to determine material functional requirements. R.E.S.

N79-27655 Florida Solar Energy Center, Cape Canaveral.
THERMAL PERFORMANCE EVALUATION OF THE SEMCO (LIQUID) SOLAR COLLECTOR

May 1979 39 p Prepared for DOE
(Contract NAS8-32248)
(NASA-CR-161230) Avail: NTIS HC A03/MF A01 CSCL 10A

Procedures used and results obtained during the evaluation test program on a flat plate collector which uses water as the working fluid are discussed. The absorber plate is copper tube soldered to copper fin coated with flat black paint. The glazing consists of two plates of Lo-Iron glass; the insulation is polyurethane foam. The collector weight is 242.5 pounds with overall external dimensions of approximately 48.8 in. x 120.8 in. x 4.1 in. The test program was conducted to obtain thermal performance data before and after 34 days of weather exposure test. A.R.H.

N79-27657 Wyle Labs., Inc., Huntsville, Ala. Solar Energy Systems Div.

INDOOR TEST FOR THERMAL PERFORMANCE EVALUATION OF SEVEN ELCAM FIN-TUBE SOLAR COLLECTOR CONFIGURATIONS

Jun. 1979 33 p Prepared for NASA and DOE
(Contract NAS8-32036)
(NASA-CR-161236; Wyle-TR-531-29) Avail: NTIS HC A03/MF A01 CSCL 10A

The test procedure used and the results obtained from an evaluation test program conducted to obtain thermal performance data on seven Elcam fin-tube solar collector configurations under simulated conditions are described. These tests were made using the Marshall Space Flight Center solar facilities. The Elcam fin-tube (liquid) solar collectors each consist of an absorber plate 5.9 inches wide by 83 inches long and a type M copper tube of 0.569 inch nominal inside diameter. No cover plate was used with any of the specimens. The uniqueness of each of the seven configurations is described, and tests were performed on each separate configuration. G.Y.

N79-27658 Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena.
POTENTIAL FOR COGENERATION OF HEAT AND ELECTRICITY IN CALIFORNIA INDUSTRY, PHASE 2 Final Report

H. S. Davis, E. Edelson, A. K. Kashani, and M. L. Slonski 1 Jan. 1979 182 p refs Sponsored in part by DOE
(Contract NAS7-100)

(NASA-CR-158772; JPL-Pub-78-109) Avail: NTIS HC A09/MF A01 CSCL 10B

The nontechnical issues of industrial cogeneration for 12 California firms were analyzed under three categories of institutional settings: (1) industrial ownership without firm sales of power; (2) industrial ownership with firm sales of power; and (3) utility or third party ownership. Institutional issues were analyzed from the independent viewpoints of the primary parties of interest: the industrial firms, the electric utilities and the California Public utilities Commission. Air quality regulations and the agencies responsible for their promulgation were examined, and a life cycle costing model was used to evaluate the economic merits of representative conceptual cogeneration systems at these

sites. Specific recommendations were made for mitigating measures and regulatory action relevant to industrial cogeneration in California. Author

N79-27659*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. PROCEEDINGS OF THE DISTRIBUTION AUTOMATION AND CONTROL WORKING GROUP. VOLUME 2: PROCEEDINGS

R. Caldwell Mar. 1979 127 p Working Group held at Baltimore, 20-22 Nov. 1978 Sponsored in part by DOE (Contract NAS7-100) (NASA-CR-158769; JPL-Pub-79-35-Vol-2) Avail: NTIS HC A03/MF A01 CSDL 10B

The meeting provided a forum in which electric utilities could communicate with each other, with DOE, and with DOE's contractors regarding research, development, and demonstration efforts to apply DAC (Distribution Automation and Control) to the electric power system. In the discussions emphasis was to be placed on identifying the priorities and needs for DAC development. Author

N79-27660*# Jet Propulsion Lab., Calif. Inst. of Tech., Pasadena. THE EFFECTS OF REGIONAL INSOLATION DIFFERENCES UPON ADVANCED SOLAR THERMAL ELECTRIC POWER PLANT PERFORMANCE AND ENERGY COSTS

A. F. Latta, J. M. Bowyer, T. Fujita, and P. H. Richter 15 Mar. 1979 116 p refs Prepared for DOE (Contract NAS7-100; JPL Proj. 5102-115) (NASA-CR-158768; JPL-Pub-79-39; DOE/JPL-1060-17) Avail: NTIS HC A06/MF A01 CSDL 10B

The performance and cost of the 10 MWe advanced solar thermal electric power plants sited in various regions of the continental United States were determined. The regional insolation data base is discussed. A range for the forecast cost of conventional electricity by region and nationally over the next several decades are presented. S.E.S.

N79-27661*# South Dakota School of Mines and Technology, Rapid City.

SOLAR ENERGY SYSTEM INSTALLED AT MOUNT RUSHMORE NATIONAL VISITOR CENTER IN KEYSTONE, SOUTH DAKOTA Final Report

Jun. 1979 42 p Sponsored by NASA (Contract EX-76-C-01-2399) (NASA-CR-161238) Avail: NTIS HC A03/MF A01 CSDL 10A

The design and installation of the solar energy system installed at the Mount Rushmore Visitor Center is described. The system was designed to furnish about 45 percent of the heating for the total facility and about 53 percent partial cooling for the 2000 square foot observatory. R.E.S.

N79-27665*# National Aeronautics and Space Administration, Lewis Research Center, Cleveland, Ohio.

ENERGY AND COST SAVING RESULTS FOR ADVANCED TECHNOLOGY SYSTEMS FROM THE COGENERATION TECHNOLOGY ALTERNATIVES STUDY (CTAS)

G. D. Sagerman, G. J. Barna, and R. K. Burns 1979 22 p Presented at AIAA Terrestrial Energy System Conf., Orlando, Fla., 4-6 Jun. 1979 (Contract EC-77-A-31-1062) (NASA-TM-79213; DOE/NASA/1062-79/2; AIAA-78-1000) Avail: NTIS HC A02/MF A01 CSDL 10A

An overview of the organization and methodology of the Cogeneration Technology Alternatives Study is presented. The objectives of the study were to identify the most attractive advanced energy conversion systems for industrial cogeneration applications in the future and to assess the advantages of advanced technology systems compared to those systems commercially available today. Advanced systems studied include steam turbines, open and closed cycle gas turbines, combined cycles, diesel engines, Stirling engines, phosphoric acid and molten carbonate fuel cells and thermionics. Steam turbines, open cycle gas turbines, combined cycles, and diesel engines were also analyzed in versions typical of today's commercially available technology to provide a base against which to measure the advanced systems. Cogeneration applications in the major

energy consuming manufacturing industries were considered. Results of the study in terms of plant level energy savings, annual energy cost savings and economic attractiveness are presented for the various energy conversion systems considered. R.E.S.

N79-27667# Bechtel National, Inc., San Francisco, Calif. COAL ENERGY CONVERSION OPTIONS FOR NAVY BASES Final Report, Dec. 1978

A. I. McCone, J. D. Ruby, J. W. Dolloff, T. P. Chen, and U. J. Yim Mar. 1979 116 p refs (Contract N68305-78-C-0036; ZF57571001) (AD-A067463; CEL-CR-79.005) Avail: NTIS HC A06/MF A01 CSDL 10/2

An overview evaluation of technologies through which coal may replace oil or gas as the primary fuel at Navy bases was performed. Four technologies for manufacturing and utilizing synthetic fuels were considered commercial. These were: low-Btu gas, medium-Btu gas, synthetic natural gas (SNG), and methyl fuel. These technologies were compared with boilers firing cleaned coal or Western coal and with boilers plus scrubbers firing high sulfur Eastern coal. The comparisons were made for a Navy base with a single central 250 x 1,000,000 Btu/hr boiler station, and for four other Navy base configurations with decentralized boilers. The clean coal firing technology led to lower costs than the synthetic fuel technologies in all cases. Medium-Btu gas offers lower costs than coal-fired boilers plus scrubbers in the most decentralized scenario. Fluidized bed combustion, judged to be a future technology, appears to be the lowest cost technology in central plants. Future environmental regulations may preclude burning cleaned or Western coals without SO₂ removal. Author (GRA)

N79-27668# Sandia Labs., Albuquerque, N. Mex. ANALYSIS OF THE POTENTIAL OF WIND ENERGY CONVERSION SYSTEMS

Jack W. Reed 1979 24 p refs Presented at Conf. on Energy Alternatives, Honolulu, 9 Jan. 1979 (Contract EY-76-C-04-0789) (SAND-78-2099C; Conf-790114-1) Avail: NTIS HC A02/MF A01

The flow of solar energy and wind was reviewed. The time and space distribution of useful wind power are described. Some of the modern machinery that was conceived to capture wind energy was considered. Some limitations to practical wind energy extraction are presented. Available and projected wind power hardware systems are summarized. DOE

N79-27669# California Univ., Livermore. Lawrence Livermore Lab.

PRELIMINARY RESULTS OF TESTS OF PROPRIETARY CHEMICAL ADDITIVES, SEEDING, AND OTHER APPROACHES FOR THE REDUCTION OF SCALE IN HYPERHALINE GEOTHERMAL SYSTEMS

J. E. Harrar, F. E. Locke, C. H. Otto, Jr., S. B. Deutscher, R. Lim, W. P. Frey, R. Quong, and L. E. Lorensen Feb. 1979 37 p refs (Contract W-7405-eng-48)

(UCID-18051) Avail: NTIS HC A03/MF A01

Sections of steel pipe and perforated screens were exposed to the treated brine. Silica precipitation rates in the effluent brine were measured by means of the electrochemical linear polarization resistance technique. Examination of the pipe sections and chemical analysis of the scales were not complete. None of the additives effected a dramatic reduction in scaling rate. Only hydroxyethylcellulose retarded the rate of precipitation of silica in the effluent brine. Scaling rates could not be measured accurately in the seeding experiment because of its short duration. DOE

N79-27670# Sandia Labs., Albuquerque, N. Mex. Advanced Energy Projects Div.

AERODYNAMIC PERFORMANCE OF THE 17-METRE-DIAMETER DARRIEUS WIND TURBINE

M. H. Worstall Jan. 1979 60 p refs (Contract EY-76-C-04-0789)

(SAND-78-1737) Avail: NTIS HC A04/MF A01

A two-bladed 17-meter Darrieus vertical-axis wind turbine was field-tested at the Sandia Laboratories wind turbine site.

Performance results for seven constant operating speeds are presented along with a discussion of the trends. Predicted performance and experimental test data for two constant speeds are compared. DOE

N79-27672# Lincoln Lab., Mass. Inst. of Tech., Lexington.
DESIGN DEVELOPMENT AND IMPLEMENTATION OF DATA ACQUISITION SYSTEMS FOR PHOTOVOLTAIC TESTS AND APPLICATIONS PROJECT

J. D. Cremin and H. A. Fenton Sep. 1979 29 p refs
 (Contract EY-76-C-02-4094)
 (COO-4094-24) Avail: NTIS HC A03/MF A01

The rationale for the structure of the MIT/Lincoln Laboratory data acquisition system used to collect and process data from four field sites is presented. The experience gained in operation of the data system and the future trends in data acquisition hardware and the impact on a PV data management system are discussed. Detailed hardware description including component prices are included in the description of the present Lincoln Laboratory system and a description of a future PV system. DOE

N79-27673# Lincoln Lab., Mass. Inst. of Tech., Lexington.
PHOTOVOLTAIC-POWERED IRRIGATION EXPERIMENTS IN THE UNITED STATES

Ronald W. Matlin 1978 9 p refs Presented at Atelier Pompage Solaire, Perpignan, France, 3-8 Jul. 1978
 (Contract EY-76-C-02-4094)
 (COO-4094-28; Conf-780773-1) Avail: NTIS HC A02/MF A01

Topics discussed include photovoltaic agricultural testing at Mead, Nebraska and the initiation of activity to develop very small 'microirrigation' systems. The Nebraska experiment generates approximately 25-kW peak power, and tests the application of solar energy to a variety of agricultural tasks including irrigation and crop drying. At the other end of the size spectrum, a 120-watt microirrigation system built to demonstrate a possible alternative to human-powered pumping in developing countries. These two projects are summarized and data gathered during its initial operating period are given. DOE

N79-27674# Argonne National Lab., Ill.
RELIABILITY AND MAINTAINABILITY EVALUATION OF FREEZING IN SOLAR SYSTEMS

P. S. Chopra and R. M. Wolosewicz Sep. 1978 38 p refs
 (Contract W-31-109-eng-38)
 (ANL/SDP/TM-78-3) Avail: NTIS HC A03/MF A01

Based on a review of 47 operational solar demonstration sites, approximately 30% of these sites experienced freezing problems. Some of these problems were caused by inattention to engineering details. Other problems resulted from a lack of knowledge of the specific requirements of solar systems. The information reviewed on 47 of the operational solar demonstration sites indicated that water-glycol systems should provide more reliable freeze protection than water systems as long as an adequate glycol concentration is installed initially and then maintained. If glycol makeup is required, a manually operated pump is used. The water system freezing problems are due to several factors which are listed. DOE

N79-27675# Argonne National Lab., Ill.
METAL HYDRIDE SOLAR HEAT PUMP AND POWER SYSTEM (HYCSOS)

R. Gorman and P. S. Moritz 1978 8 p refs Presented at AIAA Conf. on Solar Energy, Phoenix, Ariz., 27 Nov. 1978
 (Contract W-31-109-eng-38)
 (CONF-781133-5) Avail: NTIS HC A02/MF A01

The design, performance, and cost of a solar-powered metal hydride heat pump and power system for use on a residence are presented. The system design, which is limited by heat transfer, was optimized via an iterative computer program. The design process starts with optimizing the thermal transport properties of the hydride-bed-heat exchanger, then traces temperatures and pressures through the operating cycles. The coefficient of performance (COP) of the overall systems is then determined from the thermal losses due to cycling the hydride beds and due to the auxiliary power consumed by freon pumps and air-moving fans. The system, using high temperature solar collector

input at 210 F to 280 F, provides heating with a COP of approximately 1.6 and cooling with a COP of approximately 0.6, and electrical power during spring and fall, all for a cost comparable to a solar absorption cooler. DOE

N79-27676# Oregon State Univ., Corvallis. Dept. of Oceanography.
EXPLORATION OF VOLCANIC GEOTHERMAL ENERGY RESOURCES BASED ON RHEOLOGICAL TECHNIQUES

Technical Status Report No. 3, 1 Oct. - 31 Dec. 1978
 Gunnar Bodvarsson 1978 5 p
 (Contract EY-76-S-06-2227-037)
 (DOE/ET/28453-3; RLO/2227/T37-3) Avail: NTIS HC A02/MF A01

Equipment problems and work in progress are reviewed. DOE

N79-27677# Lincoln Lab., Mass. Inst. of Tech., Lexington.
MEAD 25 KILOWATT PHOTOVOLTAIC SYSTEM

L. L. Bucciarelli, J. D. Cremin, H. A. Fenton, R. F. Hopkinson, E. F. Lyon, and W. R. Romaine Jun. 1978 6 p refs Presented at 13th Photovoltaic Specialists Conf. Wash., D. C., 5-8 Jun. 1978
 (Contract EY-76-C-02-4094)
 (COO-4094-19; Conf-780619-22) Avail: NTIS HC A02/MF A01

The collection of data on solar insolation, photovoltaic array performance, power conditioning equipment performance, and weather is summarized. A comprehensive system of sensors and data logging equipment was installed for the purpose of collecting these data. The system allows for the automatic transmission of all accumulated data on a daily basis to Lincoln Laboratory in Lexington, Massachusetts, for reduction and analysis. DOE

N79-27678# Varta Batterie A.G., Kelkheim (West Germany).
DEMANDS AND EFFECTS OF SOLAR TECHNOLOGY ON ELECTRIC POWER STORAGE

H. A. Kiehne 1978 22 p refs In GERMAN Presented at Systems Exhibition Energy within the Context of the Hannover Fair, Hannover, West Germany, 19 Apr. 1978
 (AED-Conf-78-155-047; Conf-7804102-13) Avail: NTIS (US Sales Only) HC A02/MF A01; DOE Depository Libraries

The electricity storage devices mentioned which are used today in this field of application, are well known types of accumulator batteries. Intensive work is being done to improve them and to make them suitable for solar systems. Reversible fuel cells or the AgO/Zn system are other storage devices mentioned. DOE

N79-27679# Battelle Pacific Northwest Labs., Richland, Wash.
SAMPLING AND ANALYSIS METHODS FOR GEOTHERMAL FLUIDS AND GASES

D. W. Shannon 1978 257 p
 (Contract EY-76-C-06-1830)
 (PNL-MA-572-APP) Avail: NTIS HC A12/MF A01

Test results are summarized and listed by method. Results obtained for radioactive isotopes present in the brine sample are tabulated. Summaries of values derived from the round robin raw data are presented. DOE

N79-27683# California Univ., Berkeley. Lawrence Berkeley Lab.
MODELING PASSIVE SOLAR BUILDINGS WITH HAND CALCULATIONS

David B. Goldstein 1979 9 p refs Presented at 3d Natl. Passive Solar Conf., San Jose, Calif., 11-13 Jan. 1979
 (Contract W-7405-eng-48)
 (LBL-8583; Conf-790108-3) Avail: NTIS HC A02/MF A01

An analytic model of passive solar building performance was derived. Heat balances were used on the surfaces of materials that absorb sunlight along with solutions to the diffusion equation, to derive response functions for surface temperature as a function of solar flux and ambient temperature. These expressions are combined to form building response functions. These explicit building response functions allow one to write relatively simple, analytic expressions for room temperature as a function of time

over the course of a design day in terms of ambient temperature, sunlight, and heater output. Parallels between the analytic model and computer codes can be exploited to provide a better intuitive understanding of the programs and to assist in the incorporation of accurate passive solar simulation into these codes. DOE

N79-27684# Department of Energy, Washington, D. C.
UNDERGROUND STORAGE OF NATURAL GAS BY INTERSTATE PIPELINE COMPANIES FOR 1976 AND WINTER 1976 - 1977

T. A. Pappas Dec. 1978 45 p refs
 (DOE/EIA-0151) Avail: NTIS HC A01; SOD HC

The underground natural gas fuel storage capacity, total system deliveries, and average cost of storage are reported. M.M.M.

N79-27685# Oak Ridge Associated Universities, Tenn.
ELECTRIC UTILITIES AND SOLAR ENERGY: THE SERVICE CONTRACT IN A NEW SOCIAL CONTEXT

R. W. Gilmer and R. F. Meunier Feb. 1979 43 p refs
 (Contract EY-76-C-05-0033)

(ORAU/IEA(O)-79-3) Avail: NTIS HC A03/MF A01

Proposals were advanced by both advocates and skeptics of solar energy suggesting a close merger between electric utilities and decentralized solar. It was concluded that there is a need for appropriate rate design by utilities to accommodate solar users, but that any closer merger of the two technologies is unwise. DOE

N79-27686# Department of Energy, Washington, D. C.
ENVIRONMENTAL READINESS DOCUMENT. SMALL SCALE LOW HEAD HYDRO: COMMERCIALIZATION, PHASE 3 PLANNING

Sep. 1978 32 p
 (DOE/ERD-0009) Avail: NTIS HC A03/MF A01

The potential environmental, health, and safety impacts of commercialization of small scale low head hydropower technology were investigated. A relationship was found between considered commercialization scheduling and relevant environmental research and development. It was concluded that commercialization of the technology would be impeded or prevented by either adverse findings from research, mitigation costs, or delays caused by incomplete environmental information. DOE

N79-27687# Aerospace Corp., El Segundo, Calif.
SOLAR HEATING AND COOLING OF BUILDINGS (SHACOB) REQUIREMENTS DEFINITION AND IMPACT ANALYSIS Final Report

C. K. Cretcher and W. C. Melton Jun. 1978 104 p refs
 (EPRI Proj. 553)

(EPRI-ER-808-Vol-1) Avail: NTIS HC A06/MF A01

The impact of solar heating and cooling systems on electric utilities was assessed and the requirements for the design of those systems were defined so that the impact was most beneficial to both the owners and the utilities. Details and results of the analysis of the change in utility demands due to solar heating and cooling of buildings. SHACOB implementation in the participating utilities' service areas are provided, along with the costs of SHACOB ownership and the economic impacts on the utilities. M.M.M.

N79-27688# Department of Energy, Washington, D. C.
SOLAR ENERGY FOR AGRICULTURAL AND INDUSTRIAL PROCESS HEAT

Sep. 1978 93 p
 (DOE/CS-0053) Avail: NTIS HC A05/MF A01

Projects concerning the use of solar energy in agriculture are reported. Approximately 10 projects are included. M.M.M.

N79-27689# Black and Veatch Consulting Engineers, Kansas City, Mo.
GEOLOGIC ASSESSMENT OF COMPRESSED AIR STORAGE SITES IN KANSAS Final Report

D. Berwig Aug. 1978 68 p refs Sponsored by EPRI
 (EPRI-EM-877) Avail: NTIS HC A04/MF A01

The work that was completed on the geological assessment of compressed air energy storage (CAES) in Kansas is described. The work consisted of four tasks: (1) a detailed review was made of the power generation and transmission requirements of the Kansas Utility System; (2) based on the design and operational requirements of CAES reference plants, technical, economic, and environmental site selection criteria and a site selection procedure were established; (3) candidate sites were selected and evaluated using the economic criteria developed; and (4) a site development schedule and field investigation program were developed for an air reservoir located in salt. DOE

N79-27690# Department of Energy, Washington, D. C.
ENVIRONMENTAL READINESS DOCUMENT. SOLAR: HOT WATER AND PASSIVE, COMMERCIALIZATION PHASE 3 PLANNING

Sep. 1978 28 p
 (DOE/ERD-0010) Avail: NTIS HC A03/MF A01

The characteristics of the technology was highlighted; status information was provided on the technical and environmental research and development programs; a milestone chart was presented representing a relationship between a considered commercialization schedule and relevant environmental research and development. The likelihood and consequences of adverse findings, the problems and uncertainties stemming from current or anticipated environmental regulation, and potential costs of environmental controls were discussed. On this basis, an assessment is offered of the existing or potential barriers to commercialization. A tabulation of outstanding environmental concerns is presented in an appendix. DOE

N79-27691# Oak Ridge National Lab., Tenn. Chemistry Div.
KINETICS OF SILICA DEPOSITION FROM SIMULATED GEOTHERMAL BRINES

E. G. Bohlmann, R. E. Mesmer, and P. Berlinski 1978 23 p refs Presented at the SPE Intern. Symp. on Oilfield and Geothermal Chem., Houston, Tex., 22 Jan. 1979

(Contract W-7405-eng-26)

(CONF-790108-1) Avail: NTIS HC A02/MF A01

Supersaturated brines were passed through columns packed with several forms of silica (crystalline alpha quartz, polycrystalline alpha quartz, and porous Vycor). Also silica desposition on ThO₂ microspheres and titanium powder was studied under controlled conditions of supersaturation, pH, temperature and salinity. The residence time was varied by adjustments off the input effluent solutions were determined colorimetrically by a molybdate method. DOE

N79-27692# Brookhaven National Lab., Upton, N. Y.
COMPREHENSIVE AREAL MODEL OF RESIDENTIAL HEATING DEMANDS

R. G. Tessmer, Jr. 1978 8 p refs Presented at the 2d Lawrence Symp. on Systems and Decision Sci., San Francisco, 3-4 Oct. 1978

(Contract EY-76-C-02-0016)

(BNL-24998; Conf-7810139-1)

Avail: NTIS HC A02/MF A01

Data sources and methodology for modeling annual residential heating demands are described. A small areal basis is chosen, census tract or minor civil division, to permit estimation of demand densities and economic evaluation of community district heating systems. The demand model is specified for the entire nation in order to provide general applicability and to permit validation with other published fuel consumption estimates for 1970. DOE

N79-27694# Brookhaven National Lab., Upton, N. Y. National Center for Analysis of Energy Systems.

IMPACTS OF NEW ENERGY TECHNOLOGIES AS MEASURED AGAINST REFERENCE ENERGY SYSTEMS

Morris Beller, Andres Doernberg, Alan Hermelee, and Kenneth C. Hoffman 1979 32 p refs Presented at Conf. on Energy Alternatives, Honolulu, Hawaii, 9-12 Jan. 1979

(Contract EY-76-C-02-0016)

(BNL-25475) Avail: NTIS HC A03/MF A01

A physical description of the energy flows in the system from resources to end use, augmented with compilations of

economic and environmental attributes associated with those flows, is presented. DOE

N79-27695# Brookhaven National Lab., Upton, N. Y. Policy Analysis Div.

LOCATIONAL RESPONSE TO REGULATORY POLICY: A REGIONAL ANALYSIS OF ENERGY FACILITY LOCATION
Peter M. Meier and Benjamin F. Hobbs 1978 35 p refs
Presented at 1978 Ann. Meeting of the Northeast Regional Sci. Assoc., Baltimore, 12 May 1978
(Contract EY-76-C-02-0016)

(BNL-23597; Conf-7805105-2) Avail: NTIS HC A03/MF A01

The Brookhaven Regional Energy Facility Siting Model was applied to a simulation of a number of alternative regulatory strategies that affect the location of power plants. An analysis of alternative definitions of best available control technology, as called for by the 1977 Amendments to the Clean Air Act, and associated revisions of new source performance standards, are shown to have significant influence over least cost locations of coalburning power plants, with the result that despite large reductions of SO₂ emissions under the more stringent emissions limitations, the locational shifts under cost minimizing behavior results in higher population exposure to SO₂. The impacts of River Basin Commission policy on low flow objectives and on state regulatory policy in limiting interstate power transfers are examined. DOE

N79-27699# Martin Marietta Aerospace, Denver, Colo.
A 10-KILOWATT PHOTOVOLTAIC CONCENTRATOR ARRAY

R. L. Donovan and S. Broadbent May 1978 199 p
(Contract EY-76-C-04-0789)

(SAND-78-7024) Avail: NTIS HC A09/MF A01

The design of a photovoltaic concentrator array, based on the use of an acrylic Fresnel lens to concentrate sunlight on high intensity solar cells, was optimized to obtain economical photovoltaic power generation by replacing relatively priced solar cells with low cost lenses. Major design aspects considered for optimization were the concentration ratio, size and shape of the Fresnel lens, array size and shape, structure minimization, tracking and control and the practical aspects of operation and maintenance. In addition to design of the complete array, several prototype photovoltaic concentrator module subassemblies were fabricated and delivered for evaluation. These prototypes exceed the 9.0% efficiency requirement established for this program. DOE

N79-27700# Statens Straalskyddinstitut, Stockholm (Sweden).
PRODUCTION OF HOT WATER WITH THE AID OF SOLAR ENERGY: CONDITIONS AND COSTS

Folke Peterson and Lennart Ringblom 1978 183 p refs In SWEDISH

(SIB-R-83-1978) Avail: NTIS (US Sales Only) HC A09/MF A01; DOE Depository Libraries

The conditions and the costs for the utilization of solar energy to produce hot water are discussed. Different problems connected to this production are presented. DOE

N79-27701# Health Education Authority of Louisiana, New Orleans.

GRIP-CONNECTED INTEGRATED COMMUNITY ENERGY SYSTEM. PHASE 2: DETAILED FEASIBILITY AND PRELIMINARY DESIGN, STAGE 2 Final Report

Nov. 1978 310 p Prepared in cooperation with New Orleans Public Service, Inc., La., Kidde Consultants, Inc., Belleville, N. J. and Orr-Schelen-Mayerson and Assoc., Inc., Minneapolis, Minn.
(Contract EC-77-C-02-4337)

(COO-4337-2/2) Avail: NTIS HC A14/MF A01

The plant consists of multiple fuel steam boilers, turbine generators, turbine driven chillers and necessary auxiliaries and ancillary systems. The preliminary design for these systems and for the building to house the central plant systems are presented along with equipment and instrumentation schedules and outline specifications for major components. Costs were updated to reflect revised data. The final preliminary cost estimate includes

allowances for contingencies and escalation, as well as cost for the plant site and professional fees. This design is for a facility specifically with cost burning capability, recognizing that it is more capital-intensive than a gas/oil facility. The preliminary environmental assessment is included. DOE

N79-27702# United Technologies Corp., South Windsor, Conn.
ADVANCED TECHNOLOGY FUEL CELL PROGRAM Annual Report

W. E. Houghtby, J. M. King, Jr., and R. A. Thompson 1978 114 p refs

(EPRI-EM-956) Avail: NTIS HC A06/MF A01

A subscale molten carbonate cell achieved 15,370 hours endurance with stable performance through 13,000 hours. Post test analysis showed the anode structure was stable. Shutdown of the cell resulted from edge seal corrosion; an improved seal has been demonstrated through 5,000 hours of corrosion tests and 1150 hours of cell tests. Sulfur tolerance of molten carbonate cells was found to be very low; however, sulfur removal from the cell fuel gas appears to result in acceptable power plant characteristics. Testing advanced fuel processors showed that an approach referred to as adiabatic reforming has promise for achieving acceptable performance and cost while operating on distillate fuels with higher end points and sulfur levels. Laboratory tests of a regenerable scrubber for removing sulfur from gaseous processed fuel were promising. The tolerance of phosphoric acid fuel cells to sulfur in the fuel gas was investigated. DOE

N79-27703# Solar Action, Inc., Washington, D. C.
CITIZENS' SOLAR PROGRAM: STATE REPORTS ON BARRIERS AND STRATEGIES TO RENEWABLE ENERGY DEVELOPMENT

Oct. 1978 684 p

(Contract EU-78-G-01-6308)

(HCF/U6308-01) Avail: NTIS HC A99/MF A01

Solar Action, the national Sun Day organization, in an effort to focus the energy generated by Sun Day, May 3, 1978, conducted serious form where citizens and solar activists could systematically develop their analysis as to the status of solar at home and in the nation. Reports from each state grew out of this process. The 51 state solar reports provide an overview of the current status of solar power in the United States as seen through the eyes of the most ardent promoters of this emerging energy source. Financial impediments, tax complexities, hidden fuel subsidies, licensing intricacies, educational deficiencies, governmental barriers at all levels, capital shortages, and cultural biases are a few of the subject areas discussed. Ten major groups identified and discussed are educational, financial, marketing, legal, utility, regulatory, technological, policy and social barriers, and barriers due to problems within solar industry or among solar groups. Author (DOE)

N79-27704# Oak Ridge National Lab., Tenn. Energy Div.
MARKET ASSESSMENT OF FUEL CELL TOTAL ENERGY SYSTEMS Summary Report

W. R. Mixon, J. E. Christian, W. L. Jackson, G. D. Pine, H. Hagler (Resource Planning Assoc., Inc.), R. Shanker (Resource Planning Assoc., Inc.), L. Koppelman (Resource Planning Assoc., Inc.), and D. Greenstein (Resource Planning Assoc., Inc.) Mar. 1979 117 p refs

(Contract W-7405-eng-26)

(ORNL/CON-36) Avail: NTIS HC A06/MF A01

An investigation of the potential market penetration of fuel cell total energy systems (ECTES) into the nonindustrial, single building market is summarized. Input data developed for the penetration model included size distributions of each building type and performance and cost characteristics of FCTES and competing conventional systems. Two fuel cell systems, fuel cell - heat pump and fuel cell - central boiler and chiller, were assumed to compete with two conventional systems, electric heat pump and central chiller-boiler models. Two fuel cell supply situations were considered: one in which only 40 kW(e) modules were available, and one in which a catalog of 25, 40, 100, and 250 kW(e) modules were available. Data characterizing the economic climate, the intended market, and system cost and performance were used to determine the present value of life cycle costs for each system in each market segment. DOE

N79-27705# Solar Energy Research Inst., Golden, Colo.
STORAGE SYSTEMS ANALYSIS Progress Report, 1978
 Robert J. Copeland Oct. 1978 21 p refs
 (Contract EG-77-C-01-4042)

(SERI/PR-35-101) Avail: NTIS HC A02/MF A01

The development of thermal storage technology for solar thermal power applications was documented. The Solar Energy Research Institute's role in implementation and FY79 efforts are also described. DOE

N79-27706# BDM Corp., McLean, Va.
FEDERAL PHOTOVOLTAIC UTILIZATION PROGRAM. PLANNING RESOURCE DOCUMENT
 Aug. 1978 336 p Sponsored by DOE
 (HCP/M50081-01) Avail: NTIS HC A15/MF A01

The basic information required for the development of a workable and effective Federal Photovoltaic Utilization Program was provided. The current status of the technology and industry and resultant market forecast was assessed to identify current and potential Federal photovoltaic applications; develop a preliminary program plan; and assess the costs and benefits of implementing the Program. A discussion document for use in familiarizing potential participants with the scope and structure of FPUP and in soliciting their comments on and involvement in the Program is presented. DOE

N79-27707# Technische Universitaet, Munich (West Germany).
 Lehrstuhl fuer Raumfahrttechnik.

POWERSAT: AN EVALUATION

Harry O. Ruppe May 1977 93 p refs
 (TUM-LRT-TB-22/2) Avail: NTIS HC A05/MF A01

The Powersat concept of geostationary satellite energy generation and microwave transmission to earth was evaluated. A net power output of 10 GW per station and a space system life time 30 years were assumed. Two versions, one with rotating machinery, the other with solar cells, were considered. Three transportation methods were studied. Some other alternatives are also briefly reviewed. The rotating machinery system is preferred, as compared with solar cell systems current technology because of advantages in total weight, cost, and radiation immunity. Transport with a two stage chemical carrier to a 700 km orbit and then with electric self-propulsion is also preferred. It is concluded that energy spent will be recovered in from one to four years of operation. Other economic advantages are discussed. Author (ESA)

N79-27708# Societe Nationale Industrielle Aerospatiale, Cannes (France). Div. Systemes Balistiques et Spatiaux.

DESIGN CONCEPT AND FEASIBILITY STUDY OF A FLEXIBLE DEPLOYABLE SOLAR PANEL GENERATOR USED ON A TELEDETECTION SATELLITE Final Report [SARSS: ETUDE DU CONCEPT ET DE LA FAISABILITE D'UN GENERATEUR A PANNEAU SOLAIRE SOUPLE DEPLIABLE POUR UN SATELLITE DE TELEDETECTION. VOLUME 1: ETUDE TECHNIQUE]

Barkats, Calvy, Cathala, Fagnoni, Giudicelli, Josse, Jourdan, Leclerc, Leguilly, Leroy et al Sep. 1978 249 p In FRENCH
 (Contract ESA-3542/78-F-CG(SC))
 (S-1267-CA/81-Vol-1; ESA-CR(P)-1152-Vol-1) Avail: NTIS HC A11/MF A01

The initial project concept and program for the development of 1.5 kW and 3 kW solar panels are presented. The final project objective is a twice folding 6 kW peak output solar generator to be used on a European earth observation satellite. The experience germed with the ISLA solar panel and with the space telescope is shown to be related to this project. The design of all components is discussed in detail and the planning of the successive development phases is described. Author (ESA)

N79-27709# British Aerospace Dynamics Group, Bristol (England). Electronic and Space Systems.

STUDY OF A FLEXIBLE SOLAR ARRAY GENERATOR FOR A REMOTE SENSING SATELLITE. VOLUME 1: TECHNICAL REPORT Final Report

N. B. Nye Paris ESA Oct. 1978 4162 p Original contains color illustrations 2 Vol.

(Contract ESA-3536/78-F-CG(SC))

(ESS/SS-909-Vol-1; ESA-CR(P)-1153-Vol-1) Avail: NTIS HC A08/MF A01

Feasibility of employing a roll-out solar array as the power source for a remote sensing satellite program, due for launch by Ariane in the early 1980s, was investigated. Results show that such a solar array is feasible and that design based upon the Space Telescope Solar Array meets all requirements including development timescale. Author (ESA)

N79-27712# Institut fuer Systemtechnik und Innovationsforschung, Karlsruhe (West Germany).

IDENTIFICATION OF SOCIAL AND ECONOMIC DIFFICULTIES ASSOCIATED WITH THE INTRODUCTION OF SOLAR ENERGY DEVICES Final Report

Rainer Bierhals and Guenther Schaefer Bonn Bundesmin. fuer Forsch. u. Technol. Nov. 1978 166 p refs In GERMAN; ENGLISH summary Sponsored by Bundesmin. fuer Forsch. u. Technol.

(BMFT-FB-T-78-47) Avail: NTIS HC A08/MF A01; Fachinformationszentrum Karlsruhe, West Ger. DM 34.90

An analysis of the availability of solar radiation, the performance characteristics of solar systems, and the market potential for solar components is presented. Conclusions indicate that the potential for utilizing solar technology in the Federal Republic of Germany is considerable. The most serious difficulties are the lack of economic attractiveness for individual users, the presently low level of social acceptance of the new technology, and restrictive interpretations of zoning laws and building codes. Policy measures which are being proposed include legislative and administrative steps to eliminate zoning and building code restrictions, demonstration projects in the public and private sector to improve social acceptability, and grant or subsidy programs to increase the economic attractiveness of the new technology. Author (ESA)

N79-27713# Lake Champlain Basin Study, Burlington, Vt.
ENERGY USE AND SUPPLY IN THE LAKE CHAMPLAIN BASIN Final Report

Jonas Barish (Federal Energy Regulatory Comm., Washington, D. C.) Oct. 1978 119 p refs
 (PB-293437/O; LCBS-20) Avail: NTIS HC A06/MF A01 CSCL 10B

All available information from these overlapping jurisdictions were drawn, and projected energy demands to the year 1990, are presented. It provided a thorough discussion of the utility grid system, energy supplies, load forecasts, state and federal legislation involving energy questions, energy sources - developed and undeveloped, and environmental considerations. In addition, it recommended energy actions for the basin, including a discussion of energy alternatives. GRA

N79-27730# Environmental Monitoring and Support Lab., Las Vegas, Nev.

ENERGY-RELATED AIR QUALITY MONITORING IN THE WESTERN ENERGY RESOURCE DEVELOPMENT AREA

M. L. Pitchford, R. N. Snelling, J. Bowen, M. Pearson, and D. N. McNelis Nov. 1978 62 p refs
 (PB-293160/8; EPA-600/7-78-227) Avail: NTIS HC A04/MF A01 CSCL 13B

A program designed to create an environmental data base for assessing the air quality impact of energy development in an eight state region (Arizona, Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, Wyoming) is described. The program was developed to use and augment existing monitoring activities as well as create new monitoring systems. GRA

N79-27921# Brookhaven National Lab., Upton, N. Y.
ALTERNATIVE, SEMI-AUTOMATED METHOD FOR PERFORMING MULTIOBJECTIVE ANALYSES

J. Schank Aug. 1978 99 p refs
 (Contract EY-76-C-02-0016)
 (BNL-50892) Avail: NTIS HC A05/MF A01

An automated methodology to characterize the quality of an energy system was developed. Both the previous and automated procedures are executed upon variants of the 1985

and 2000 National Energy Plan scenarios and the respective results are compared. DOE

N79-28056# Solar Energy Research Inst., Golden, Colo.
REVIEW OF SELECTED SOLAR MARKET STUDIES AND TECHNIQUES Progress Report

Don Berliner, S. Christmas, D. Costello, and C. Fellhauer Oct. 1978 58 p refs

(Contract EG-77-G-01-4042)

(SERI/PR-52-076) Avail: NTIS HC A04/MF A01

The preliminary results of a literature review of solar energy market studies in the industrial process heat, passive, solar thermal electric, photovoltaic, wind, and ocean thermal technologies are presented. Useful elements of market studies in other solar areas are described as well. The market research literature is reviewed in order to investigate techniques or approaches that may have some applicability in the context of solar markets. A preliminary plan is presented for the initiation of selected solar market studies during FY79. DOE

N79-28058# Department of Energy, Washington, D. C. Office of Regulations and Emergency Planning.

FINDINGS AND VIEWS CONCERNING THE EXEMPTION OF KEROJET FUELS FROM THE MANDATORY PETROLEUM ALLOCATION AND PRICE REGULATIONS

Dec. 1978 105 p refs

(DOE/ERA-0023) Avail: NTIS HC A06/MF A01

Based on an analysis of historic and projected supply, demand, and price trends, the DOE concluded that allocation and price controls are no longer necessary for kerojet fuel and that exemption of kerojet fuel will be consistent with the attainment, to the maximum extent practicable, of the objectives specified. DOE

N79-28059# Department of Energy, Washington, D. C. Energy Information Administration.

MIDTERM OIL AND GAS SUPPLY MODELING SYSTEM METHODOLOGY DESCRIPTION

C. Everett, N. Mahn, and K. Jones Nov. 1978 51 p

(DOE/EIA-0103/17: TM/ES/79-05) Avail: NTIS HC A04/MF A01

The Midterm Oil and Gas Supply Modeling System is a computer based model which projects domestic oil and natural gas production for 15 years based on economic and engineering factors which effect oil and gas supply. The regional oil and gas supply curves developed are input to the Project Independence Evaluation System. The Oil Supply Model consist primarily of three interconnected submodels: a drilling submodel; a resource submodel; and an economic submodel. Also included in the Modeling System is a financial model which tabulates detailed costs and revenue information calculated from the minimum acceptable price model into regional income statements and selected balance sheet items for the oil and gas producing industry. DOE

N79-28063# Argonne National Lab., Ill. Energy and Environmental Systems Div.

COMPUTER SOFTWARE FOR PLANNING DESIGN OF COMMUNITY ENERGY SYSTEMS

Veronika A. Rable, James M. Calm, and John J. Roberts 1978 7 p refs Presented at the Joint Natl. Meeting of the Operations Res. Soc. of Am. and the Inst. of Management Sci., Los Angeles, 13-15 Nov. 1978

(Contract W-31-109-eng-38)

(CONF-781182-2) Avail: NTIS HCA02/MF A01

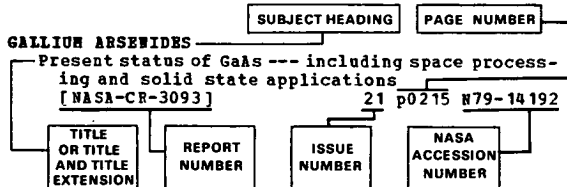
Simulation and optimization procedures for community energy systems are presented. Community systems are recognized as offering energy conserving alternative methods of meeting the energy service needs of communities. The integrated Community Energy Systems (ICES) approach is discussed. The need for sophisticated analytical methods for ICES planning and design is explored. A software series developed or under development to meet these needs is presented. G.Y.

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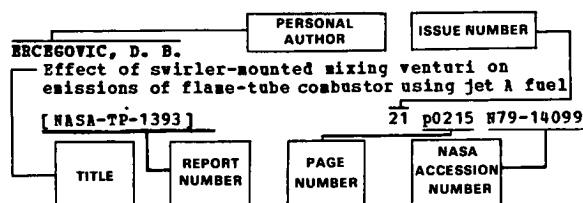
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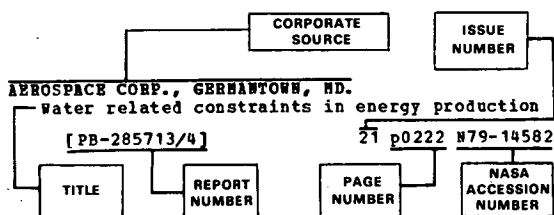
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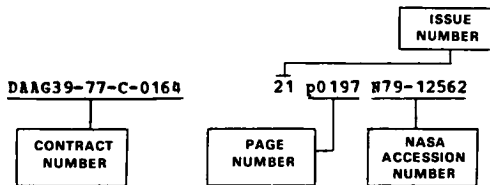
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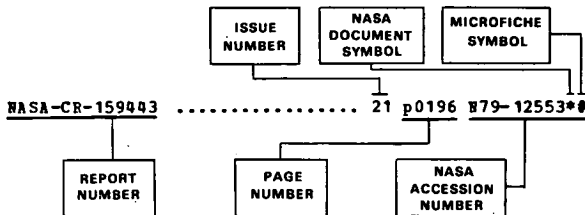
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